AN

AGRICULTURAL CLASS-BOOK

FOR THE

134 C 53

USE OF SCHOOLS IN SOUTH INDIA.

Prepared under the Orders of Government.

BY

WILLIAM R. ROBERTSON,

Member of the Royal Agricultural College; Superintendent of Government Farms in the Presidency of Madras.

MADRAS:
PRINTED BY E. KEYS, AT THE GOVT. PRESS.
1880.

PREFACE.

In this treatise an effort is made to explain, in simple terms, some of the principles on which successful agriculture is based. The book is intended to be used in Schools to enable youths to qualify themselves for the Agricultural portion of the Upper Primary and Middle School Examinations. It is hoped that the information thus obtained will be of use to those who are about to engage in agricultural pursuits, and be of service in disseminating sound views of agriculture among all classes in South India; in which all have suffered severely, especially during the past few years, from scarcity and famine, resulting mainly from bad farming.

WILLIAM R. ROBERTSON, M.R.A.C.

SCARBOROUGH,
October 13th, 1879.

CONTENTS.

		Page
Part	I.—Soils	8
,,	II.—The preparation of land for cultivation ..	29
,,	III.—Tillage Implements and Tillage operations	36
,,	IV.—Manures, Irrigation, &c	53
,,	V.—Farm Crops	63
,,	VI.—Farm Stock	72

AGRICULTURE.

INTRODUCTORY.

THE art, or science, of agriculture, includes whatever it is necessary to do, to produce field crops, farm animals, and such produce of these animals as is required. The objects of the farmer should be *the improvement of the soil in view to the production* of the largest crops of superior varieties, at the smallest expense, and at the least permanent injury to the soil; and the improvement and utilization of the races of cattle, sheep, poultry, &c., he breeds and rears.

2. You will readily understand, how very important *a correct knowledge of agriculture* is, in this Presidency, where you learn that seventy-five per cent. of the entire population depend directly, or indirectly, on agriculture for a livelihood.

3. To enable you to understand why it is now so necessary that efforts should be made to improve the agriculture of the country, I must ask you to give your careful attention to the following figures. During the twenty years ending with the year 1871, the population of Madras had added to it 9,566,175 souls, that is, the population which numbered only 22,031,697 in 1851, had increased in 1871, to

31,597,172 persons. Now, to show you how the vast addition to the demand for food and clothing was met, I must tell you that, in the period just referred to, 5½ million acres were added to the ploughed or arable area of the Presidency.

4. It will be quite clear to you, that we cannot continue adding five million acres to the area of our cultivated land in every twenty years, to supply the food of our increasing population, for already most of the land best suited for tillage is under cultivation.

5. We shall be compelled, therefore, to resort to other means, and first among these will be, the more skilful cultivation, and more generous treatment of the land, every acre of which will have to be made to yield twice as much produce as most of it has hitherto yielded.

6. But, to enable the greater demand for food to be met by the *increased productiveness of the soil*, it will be necessary first that a superior system of husbandry should be adopted.

7. The *kind of farming, which yielded results of a* fairly satisfactory kind, as long as only the moderately good soils were tilled, has failed altogether in the treatment of the inferior soils, it has now become necessary to cultivate; and these inferior soils constitute nearly the whole of the land yet remaining to be brought under cultivation.

I.—Soils.

8. *Soils.*—When travelling through the country you observe as you pass along a great difference in the color and general appearance of the soils. Thus

where you begin your journey the soil around may be black; further on it may be a dark-brown, still further on the prevailing soil may be of a reddish color, and this, as you proceed, may give place to a yellow or even a white colored soil.

9. In the mind of the observant student of agriculture, the question naturally arises, why do the soils differ so greatly in color and in general appearance?

10. To explain this fully would occupy far more time than we can devote to the subject; we may, however, obtain a good deal of useful information without going very deeply into the matter.

11. *Black Cotton Soil.*—On glancing over a field of black cotton soil you will probably notice that the color is very uniform over the whole area, and on further observation you will be likely to note that a large area of the surrounding country consists of similar soil. If you have holes dug in the soil, you will find that its depth varies from six inches to two or three feet. If you ask the cultivators of similar fields in the neighbourhood, they will tell you that this layer of black soil is in some places as much as twenty feet in thickness.

12. If you examine next the soil removed from these test holes, you will find it fine in texture, free from small stones, moist, of a dark black color, and beneath the surface somewhat sticky.

13. If you ask the cultivator for further particulars, he will tell you that the soil is a difficult one to till, it gets so hard in the dry weather, when it becomes cracked in all directions, and, in wet weather, is very sticky.

14. The crops on this soil, are chiefly cotton and cholum (*Sorghum vulgare*). You know that the cotton plant matures its produce in the dry season. To maintain the proper growth of the plant, at this important period of its life, moisture is, of course, required. This, the black cotton soil is able to furnish, from the property it possesses of attracting moisture from the air, and storing it up.

15. From the results of some experiments made at the Saidapet Farm, it was calculated that an acre of ordinary black cotton soil, to a depth of 6 inches, contained sixty tons of moisture, whilst a similar area of the sandy soils of the farm, to the same depth contained only 7½ tons, both soils being similarly exposed, and, on further inquiry, it was ascertained that, while the black soil contained about 50 tons of vegetable matter per acre, the sandy soil contained less than 20 tons.

16. It has been clearly proved that soils, which contain a fair quantity of vegetable matter—the *remains of dead plants, &c.—are always damper, than* soils which contain a small quantity of this substance The additional moisture is taken up chiefly from the air at night.

17. You will, of course, understand that this black cotton soil did not always exist in the state in which you now find it. What the exact origin of the soil was, we cannot be quite sure.

18. We know that black soils are formed by decaying vegetable matter with admixtures of other materials; the formation of black soils in this way is going on regularly in forests where the fallen leaves,

and the remains of dead plants, provide the vegetable matter, and you must have observed that the bottoms of tanks are frequently covered with black mud; this black mud was derived partly from soil carried into the tanks in the flowing water, and is partly due to the remains of aquatic plants, which have grown and died in the tanks.

19. Now, these black cotton soils may have been formed in either way, the land which the soil now covers may have been, ages ago, the bed of a shallow lake. It is true that you often find this black cotton soil, resting on elevated table-land where there are no hollows, of the kind you would expect shallow lakes to occupy; but we know that under the operations of volcanic agencies, the surface of land is often greatly altered, and it is possible that the beds of what were shallow lakes, may have been raised; we know, that shallow lakes are often filled up by the accumulation of silt.

20. On the other hand, the black cotton soil may owe its origin directly to the decay of forest vegetation, *fallen leaves, &c., during a long period of years,* but if this was so we would expect to find some evidences of the previous existence of such large forests in the soil itself, but these evidences are absent, as far as has yet been ascertained.

21. Chemistry tells us that these black cotton soils are generally rich in the food of plants, except lime, and that the defects of these soils are chiefly to be attributed to their bad physical conditions; defects *that it is in the power of the intelligent agriculturist,*

to ameliorate or remove, by proper tillage, and by using suitable manures.

22. It is highly improper to attempt to plough an ordinary stiff black soil when, after rain, it is saturated with water, for, if you ploughed it in that state, the soil would be worked into a paste, which, on drying, would be hard and difficult to pulverise.

23. You must remember that one great aim of the husbandman in conducting his tillage operations is to reduce the soil to fine particles. If the soil is badly tilled, that is is in lumps, there is not nearly so much of its fertilizing matter available for the use of plants as when the soil is finely pulverised.

24. Black cotton soils may, generally, be deeply ploughed without any ill results arising therefrom. Still, it is unwise, even with such soils, to adopt deep ploughing at once. If you wish, say to plough four inches deeper than you have hitherto done, it is better to effect this in from three to four years, rather than in one year. But, before you decide what to do in such a matter, it will always be safest for you to make a small experiment.

25. You may, however, deepen your soil at once, without a possibility of any evil resulting therefrom, if instead of doing this by means of the plough, you produce the deeper tillage by using the cultivator or the subsoil plough, implements which stir and loosen the soil, but do not bring up the under soil to the surface.

26. As we have already seen, these black cotton soils, are usually rich, in most of the elements of plant food, still they require manure, especially

lime. Not only will the lime supply what the soil is deficient in, and therefore requires; but the lime acts beneficially on the soil itself. Owing to the general absence of lime in these black soils, the crops produced on them are not so diversified as is desirable. A dressing from 1,000 to 5,000 lbs. of lime may be applied per acre, according to the price at which the lime can be obtained.

27. Manures, which will render the working of these black soils more easy, are especially to be recommended, these may be village ashes, the ashes of brick kilns, sand, farm-manure, green-manure, &c. There are many other manures, such as broken bones, saltpetre, gypsum, &c., which may be applied with special reference to the wants of the crops it is intended to cultivate.

28. The brick kiln ashes, and the sand, will alter the texture of the soil, and make it less liable to contract, and crack, and render it more easy to till. The village ashes, which consist of the ashes of cowdung and of the wood used as fuel, will act in much the same way, but if they have been properly stored, that is, protected from the washing effects of rain, they will afford potash and other valuable plant foods.

29 Farm manure which, when properly made, consists of the litter, straw, leaves, &c., used in bedding, and the dung and urine of cattle, horses, sheep, &c., is a valuable manure for any kind of soil, but is especially valuable when used in a partially decomposed state for black soils. The manure, when used in this state produces certain important

mechanical changes in the condition of the soil, which greatly facilitates its cultivation; while, at the same time, the manure, if good, adds valuable fertilizing agents to the soil.

30. Green manures you must understand are crops ploughed into the soil, while living, for the purpose of enriching it, or altering its mechanical texture. Any crop of which the plants are succulent, robust, and sufficiently bulky will suffice, but, leguminous, that is pod-bearing plants, are the best suited. Such crops are simply ploughed under the soil.

31. You will now be prepared to form the opinion that, these black soils are valuable, their capabilities being so great when properly farmed.

32. So far, we have been considering the properties, characteristics, and uses of the soil, generally recognized in this Presidency, as, the "black cotton soil."

33. *Black Alluvial Soil.*—There are, you must remember, other kinds of black soil, thus, in low swampy situations where large rivers enter the sea, and on the borders of rivers, lakes, and tanks, you frequently find a soft tenacious black colored soil. Sometimes this is only semi-liquid mud, and of little or no use for cultivation; at other times, it is met with of a much firmer consistency, and when not liable to be submerged to any serious extent, is used for the cultivation of paddy. Such soils are clearly of alluvial origin, that is, they have been formed by the accumulation of silt, deposited from water.

34. You are familiar with the muddy appearance of the water of rivers, tanks, &c., after heavy rain;

this muddy appearance is due to particles of soil carried by the water. If you fill a tumbler with this turbid water, you will observe that, there are countless numbers of earthy particles suspended which makes the water of a black or brownish color. Leave the vessel standing, and on examining the water a few hours later, you will see that it is clearer, while a thin layer of earthy matter is forming on the bottom of the vessel; this layer consists of the heaviest particles which sink first on the water becoming still. Wait longer and again inspect the water, this time you probably notice that it is nearly clear, showing that it has lost nearly all the matter that was suspended in it, which you find deposited on the bottom of the vessel.

35. What you saw carried out on a small scale, is exactly what is done on a grand scale by natural agencies, the silt which was deposited is the raw material of which black alluvial soils are formed.

36. The earthy matter which discolors the water of rivers, and tanks, after heavy rain is washed off higher lands by the rain water as it flows over the surface of the ground in its passage to the tanks and rivers.

37. *Black Peaty Soils.*—Another description of black soil, met with on the Nilgiri Hills, chiefly in hollows, is called peaty soil: this is formed chiefly by the partial decay of vegetable matter, the remains of many generations of, usually, semi-aquatic plants that have grown and died in the place.

38. Peaty soil is not met with in the plains, where, owing to the much greater heat, decomposi-

tion always proceeds more rapidly and is more complete.

39. These peaty soils when they contain a fair admixture of clay, or sand, are when well farmed, frequently very *productive.* When they consist chiefly of vegetable matter, they are usually infertile *and fitted only for use as fuel, for which purpose,* when properly dried, and prepared, peat is largely used in some countries.

40. *Brown Loamy Soil.*—Let us now examine a field of brown loamy soil. You will observe at once, that the soil is not uniform in color over the whole field, and that, in the neighbouring fields, the soil differs greatly in general appearance. This soil, you will see, does not form extensive plains like the black soil.

41. We will examine the soil by digging a few test holes in different parts of the field. Some of these holes we will make 6 inches deep, the remainder 1 foot.

42. The soil removed from the shallow holes is loose and is mixed with a few small stones. When pressed in the hand the soil does not retain the shape given to it by the hand, but remains powdery, we say therefore that it is a friable soil.

43. The soil removed from the deeper holes is, you will notice, lighter in color, is sticky to the touch, and when you take a handful of it and press it, it retains the form given to it by the hand. Hence, we say that the undersoil is stiffer and more adhesive, and as we know that these are the

properties of clay, we conclude that the undersoil contains more clay than the surface soil.

44. We have now obtained a sample of the soil, and of the sub-soil; that excavated from the shallow holes being representative of the soil; and that from *the deep holes of the sub-soil.*

45. The soil is the upper layer of the ground which is usually moved by the tillage implements and through which the roots of plants spread and seek for food; the sub-soil is the layer which lies immediately beneath.

46. Sometimes there is a close resemblance between the composition of the soil and the sub-soil, and in the instance just noticed, the darker color of the soil may be attributed to decaying vegetable matter.

47. The material formed by the partial decomposition of vegetable remains is called *humus*, its *color varies from a dark-brown to a black. When* present in a large quantity, humus darkens the color of the soil. The lighter color of sub-soils is due to the smaller quantity of humus they contain.

48. You remember that we found the sub-soil sticky, and adhesive, and that a handful of it could be pressed into a ball; and that we inferred from this, that the sub-soil contained a considerable amount of clay.

49. Those of you who have seen bricks and pottery made, are aware, how sticky and tenacious clay is, when moist. And you probably all know, how powdery is the sand on the sea shore and in river beds. Now, *most soils are composed chiefly of sand*

and clay, mixed more or less intimately together; if, the sand is present in large quantities, the soil is open, friable and, easily tilled; but, if clay predominates, the soil *is stiff, tenacious and difficult to till.*

50. A loamy soil contains not more than 50, nor less than 30 per cent. of clay, not more than 5 per cent. of lime, about the same quantity of humus, and the remainder sand.

51. Loamy soils are useful soils. They usually contain a fair proportion of plant food, retain moisture much better than sandy soils, and are much more easily worked than clay soils.

52. The *value of land depends very much on the nature of the sub-soil.* In hot dry weather while the crops on land with a porous sub-soil are withered from want of moisture, the crops on land having a moderately stiff sub-soil, are frequently at the time, green and luxuriant.

53. It is desirable that the sub-soil should be somewhat stiffer than the surface-soil, not only because land with such a sub-soil is enabled to store up more water for the crop it bears, but because manure is better utilized. When a sub-soil is formed *of gravel or coarse sand, rain water filters down* through it too quickly, and, in doing so, carries down with it much of the manural matter that has been applied to the soil. Such open sub-soils are termed hungry sub-soils.

54. We learn from chemistry that we may expect to find in a soil, such as that we are now considering and other good soils, the following:—

organic matter, alumina, silica, and lime, and small quantities of soda, magnesia, potash, ammonia, oxide of iron, carbonic acid, sulphuric acid, chlorine, &c.

55. By certain processes he carries out in his laboratory, the chemist can separate and weigh the different constituents of a soil. He first separates the organic matter, next the silica, next the alumina, and so on with each of the constituents. These constituents are found in varying proportions in all fertile soils whatever their color or general character.

56. In its passage through a loamy soil, the plough meets with far less resistance than when passing through an ordinary black soil, or clay soil, and, if you notice the working parts of the plough, you will see that they are much cleaner and freer from adhering earth. Hence such a soil is termed a free soil; and also a light soil because the implements of tillage when at work in it are of lighter draught, compared with their draught when working in some other kinds of soil. The draught of an implement is the amount of force needed to drag it.

57. The term "heavy," as applied to a soil, means that the soil resists the passage of implements through it with considerable force, demanding the employment of great power in effecting this.

58. You will understand therefore that a soil that works freely is a much cheaper one to cultivate, than a heavy soil. But a free soil possesses another advantage, viz., in being capable of being worked during a greater number of days in the year than a

heavy soil; a shower of rain, which might render a heavy soil so sticky and adhesive for several days afterwards, as to be unfitted for ploughing, might on the lighter soil facilitate rather than check tillage operations.

59. *Red Soils.*—It is desirable that we should now give some little attention to the red soils which, in some parts of our Presidency, cover such a large area of country. In color they vary from a pale red to a dark red approaching to a chocolate color.

60. There are red clays, red loams, and red sands and, of course, the character of the soil will be as varied. Usually the red soil found in the neighbourhood of extinct volcanos contains a good deal of sand, is friable and productive.

61. The red soil in other parts of the Presidency contains much clay, and is apparently a sedimentary deposit, is thin, difficult to work, and not unfrequently is quite sterile, in its natural condition. Such a soil is known as laterite soil.

62. The red soils of the better class are valuable soils, and are fitted for all kinds of crops, for leguminous crops, however, they need to be limed.

63. If during a drought you inspect the crops on a red sandy soil, and those on a white colored sandy soil, you will observe that those on the former soil are healthy and of a dark bluish-green color, while the crops on the yellow or white colored sand are of a pale color and are languishing. This difference in the crops must be attributed to the presence of oxide of iron in the one soil, and the absence of it in the other soil. The red color of the soil is due to oxide

of iron and this enables a soil to take up moisture from the air in a greater quantity.

64. This oxide of iron is similar to the red rust you observe on the ploughshare after it has been lying aside for sometime. Oxide of iron is one of the foods of all cultivated crops, in the ashes of all of which you always find oxide of iron, and in some cases in considerable quantities.

65. For irrigation, red soils are generally not well suited, as they usually contain too much clay. When, however, they consist chiefly of sand, as they do in some parts of the country, they may be irrigated with great advantage.

66. *Light-colored Soils.*—Those of you, who have travelled in various parts of the Presidency are aware, that the soils now under notice are much the most prevalent, and those of you who have mixed much with cultivators know, that usually they do not put a high value on these soils.

67. You cannot fail in having noticed how varied in character are these soils.

68. Where this kind of land is elevated you will frequently observe that the soil is covered with innumerable fragments of grey and white colored rock, of all sizes below that of a cocoanut, with occasionally pieces of a much greater size, and large rocks may protrude through the soil in some places.

69. If you take a hammer and break off a piece of one of those rocks, you will probably find that the fragment resembles the pieces scattered over the land, and the fact may be that they are similar, the fragments scattered over the land being pieces of

similar rocks that have been broken up by natural agencies.

70. Here let us pause for a while to consider the nature of these natural agencies, and the effects they produce. The agencies are the air, and its gases, water, heat, &c.

71. The air and its gases operate on the surface of rocks physically and chemically.

72. The air is composed chiefly of two gases, one called oxygen, and the other nitrogen. In one hundred cubic feet of air there are twenty-one cubic feet of oxygen and seventy-nine cubic feet of nitrogen. Besides these gases there are also in the air varying quantities of carbonic acid and watery vapour.

73. The presence of carbonic acid in the air is due chiefly to the quantity of this gas which animals are constantly giving off from their lungs, in the act of breathing, and also to some extent to combustion, the decay of organic matter, &c.

74. In the destruction of rocks the oxygen and the carbonic acid of the air enter into combination with some of the minerals of the rock, and the new compounds thus formed, being softer than the original rock, are more readily washed away by rain falling on the rock, thus making holes or cavities in which water lodges, and in so doing softening the adjoining parts, and making them still more accessible to the destructive agents. In this way the disintegrating work goes on with increasing force. In some instances the surface of the rock is only gradually reduced, that is, the work of destruction is

less discernible. You are aware that the rock is being worn away, only by the rounded appearance of its edges. At other times the rock breaks up into large blocks, and these blocks again by similar means become broken up into smaller pieces, which in turn become still further reduced until they form what is termed gravel, and the gravel in time becomes reduced into a powder which we call sand. Thus you will see sand is but rock powder.

75. Remember that soils are composed chiefly of rock powder, and that therefore the character or value of soils depends greatly upon the kind of rock or rocks from which they have been formed; thus, a soil formed chiefly of the powder of a felspar rock, is much more valuable than one formed of powdered quartz rock; the felspar rock probably contained potash and other valuable plant foods, which quartz rocks do not contain.

76. You are familiar with the effects produced by moving water in *wearing away rocks*; *you have seen* in the beds of rivers how flowing water cuts its way through even the hardest rocks.

77. In cold countries frost has a very powerful *effect in breaking down and pulverizing rocks.* Water finds its way into the rock, either by means of crevices or holes, or is absorbed into its fine pores. The water on freezing expands, and in this way breaks up the portions of the rock near, which, on a thaw occurring, crumble away.

78. In this country great heat, and sudden changes from hot to cold prove frequently very destructive to rocks. The great heat intensifies chemical action,

and sudden changes of temperature cause contraction or expansion and consequent displacement of the particles of the rock affected. You know that quarry men frequently take advantage of this circumstance; they light fires on the rock they wish to quarry and after the rock has become sufficiently heated, they suddenly throw over it large quantities of cold water; the result of which is that the rock is cracked in various directions.

79. You have now learned something of the means by which soils are formed, let us resume our inquiries regarding the light colored soils forming slightly elevated tracks of country termed "uplands." We were, you will remember, considering the peculiarities of one of these soils covered with stones. Such soils are usually shallow and of a coarse texture. The crops on them wither during a drought, their roots are so near the surface, and such soils have but little power of absorbing vapour from the air.

80. If we are correct in believing that the fragments of rock, usually scattered over such soils, are gradually being reduced under the action of air, &c., and that these influences have been long operating in this way, there should be a considerable quantity of fine rock powder to constitute a soil of sufficient depth; what then has become of this soil.

81. Much of the fine earth naturally formed by the disintegration of the rock fragments, is washed off the surface of the land during heavy rain and is carried by the flowing water on its descent to lower land, where the earthy matter is deposited and if it contains fertilizing matters, the land is enriched.

82. In this way, the soils of the higher elevations are gradually being robbed, while the material carried away goes to deepen, and generally, to enrich the soils of lower elevations, or is carried by the river into the sea, there to be deposited, and, in time, to form new land.

83. *Much of the land in this* Presidency *to which* I am now alluding is very poor, and thin, from its *finer particles being carried away after every heavy* fall of rain.

84. It is not always advisable *to gather* and remove all the stones scattered over a field, unless indeed they are so very abundant, or are so large, as to interfere with tillage operations. Thus for instance, the stones may be pieces of a limestone rock and under the influences of the air may be gradually affording lime to the soil over which they are scattered.

85. Instances have been known of land becoming less productive on its surface stones being removed, but only when the stones were capable of affording on their gradual destruction, lime, or some other mineral useful to plants.

86. The light colored soils in low situations, especially in beds of valleys, are not unfrequently stiff clays. Such soils are, as we have already learnt, formed by materials deposited from water, which *it* had removed from higher land. These soils are *usually fine in texture, and they become full of cracks* after a long drought. The cracks are due to the *contraction of the soil. As* a rule such soils *are not* easy to work they are either too hard, or too sticky, and being frequently found occupying the

beds of basins, with imperfect natural drainage, are often difficult to improve, where however they can be improved by drainage or other means they make valuable soils. It is the great power of holding water they possess that makes them so difficult to till, *but this property, if not in excess, is a valuable one* in a tropical climate, in enabling a soil to mature, during a drought, a crop that on a sandy soil would almost fail.

87 As a rule clay soils are rich in plant food, manure applied to them is always more thoroughly used, instead of being wasted by being washed out of the soil, a result that often occurs in the case of a very sandy soil. An application of lime has frequently a very good effect on a clay soil provided its pores are not filled with water at the time.

88. Very stiff clay soils may be rendered less stiff, and therefore easier to cultivate by burning the *upper four inches, and working* the ashes *into the* soil; or the same result may be secured, by spreading coarse sand over the soil and ploughing it in.

89. *Stiff clay soil is unfitted for being irrigated,* unless great precautions are taken both in applying the water, and to secure its removal after it has done its duty.

90. Clay soils are of various *colors,* red, black, yellow and grey. The color does not always afford an indication by which alone you may judge of the character of a soil; *for you may have a red soil com*posed of either clay, or of sand; or of clay and sand mixed, &c. However, in this country, the color, *affords a clue to the character of a soil, which is*

of great use, when other facts regarding the soil are known.

91. In many parts of the Presidency, especially near the coast, there are tracts of light colored soil forming plains of considerable extent. These are chiefly sandy soils formed of granular particles, sometimes coarse and, at other times, fine. As you have been informed sand is but rock powder, and the powder of a quartz rock only, is almost worthless for agricultural use.

92. The fertility of a sandy soil, then, depends greatly upon the admixture with it of materials that afford plant food. Some sandy soils are largely mixed with fertilizing materials.

93. Sandy soils form some of the poorest tracts of country known, while some of the most productive land is composed chiefly of sandy soil.

94. Sandy soil of a good character, and here, let me point out to you that there are white, yellow, brown, black and red sands, are the best suited for irrigation, water can filter down through, and be most effectually used, on such soils.

95. Of course if the quantity of water available for use in irrigation is very small, it will produce a greater effect, when applied to a moderately stiff soil, than to a very sandy one, but for regular irrigation when manure is used in a sufficient quantity, a sandy loam is the best suited.

96. Sandy soils, if of inferior character, are very unprofitable in a tropical country for culture without irrigation water. Crops on such soils suffer severely in a moderate drought, and in a continued drought

die off altogether; the retentive powers of these soils can be increased by heavy applications of clay, or by growing crops for ploughing into the soil as manure. However they are also poor and need much manure, which is often greatly wasted from the soil being unable to retain the manure when the land is washed by heavy rain. Sandy soils are however cheap to cultivate as a rule, from the greater number of days during which they can be tilled, and the less resistance they offer to the tillage implements compared with clay.

97. *Limestone Soils.*—Another variety of light colored soil is met with in some places which owes its light color to the presence in it of a large quantity of lime. You must not however conclude that a soil must necessarily be of a white color because it contains much lime, for lime is met with sometimes that gives a bluish and sometimes a yellow tint to the soil.

98. Soils that contain much lime are fertile if of sufficient depth, but as they are usually met with they are thin, and this is a serious objection in a tropical climate, where, in the periods of cultivation, long droughts frequently occur. These soils are of special value for the production of leguminous, that is, pod-bearing plants, indigo, gram, &c., which are lime feeders.

99. Soils have been classified in many different ways; the most simple is the following:—

Clay soil ..	A soil	containing	above 50 per cent. of clay.
Calcareous soil.	Do.	do.	above 20 per cent. of lime.
Sandy soil ..	Do.	do.	above 80 per cent. of sand.
Peaty soil ..	Do.	do.	above 15 per cent. of organic matter.

100. You will now understand that there is much to be learnt regarding soils, though we have as yet but glanced only at some of the matters of greatest interest connected with them.

II.—The Preparation of Land for Cultivation.

101. Some land is fitted at once for ploughing, but generally much preparatory work must be done before the plough can be used advantageously, on land that has not previously been cultivated.

102. Most of the land covered by forest, and scrub jungle, is rich and well worth cultivation, and, when it is desirable to bring such land under tillage, it is of course necessary to remove the trees and brushwood.

103. But it is not always expedient to clear forest land. To do so in some instances, may be very unwise, both as regards the interests of those residing in the neighbouring country, engaged in agriculture, and also as regards the interests of the intending cultivator, of the land to be cleared. Of course, before tillage operations can begin, the trees and shrubs on the land must be removed. However, it is seldom necessary to remove all the trees and shrubs, and it is often desirable that belts of trees and shrubs, should be left in certain situations, to afford shelter and protection to the crops, and stock in severe weather. Remember always that you may in a very short time cut down trees which may have taken a life-time to grow.

104. Much injury has been done in this Presidency by the indiscriminate clearing of forest. Trees are

of great use in equalizing the rainfall and temperature of a locality. The severe droughts and high floods, experienced in some parts of the Presidency, have been with good reason attributed to the unwise destruction of forest in the surrounding country.

105. As has been stated, tillage husbandry cannot be practised on land covered by trees. When therefore *such land must be appropriated for culture you* have no choice but to remove most of the trees.

106. In situations where the timber can be utilized, the best portions should of course be made use of. Sometimes the whole of the trees and shrubs are burnt on the land, but this is a very wasteful practice, and justifiable only under very exceptional circumstances.

107. After removing the best of the timber, the remainder with the shrubs, &c., should be burnt on the land, and the ashes made should be carefully distributed over the surface, and mixed with the soil. It is very unwise to leave the heaps of ashes *standing on the land, if the weather is at all showery* at the time, as the valuable portions of the ashes are soluble, and therefore are readily washed away by the falling rain.

108. The removal of some forest being unavoidable, it becomes necessary then to consider in what way we can compensate the country, for the loss of the trees. There are thousands of acres of land in all parts of the Presidency, unfitted for tillage, which might, with great advantage, be planted with trees, and every farmer should make it his duty to plant fruit trees near his dwelling, and fuel trees and live

fences in suitable parts of his farm. By such means, *in portions of the country where the climate has* been injured by the indiscriminate clearing of forest, &c., much good might be done. Most of the holdings in this country are almost perfectly bare, and the advantages, the occupiers themselves would gain, would be great by planting live fences, fuel trees and fruit trees.

109. Some land, *before it can* be profitably cultivated, needs to have its surface levelled, especially if the land is to be irrigated, or if the rainfall of the locality is very great. Land with a somewhat level surface, is generally more valuable than that which is very steep. You may sometimes, at a moderate expense, do a great deal of good, in correcting the inequalities of the surface of your land, but there is some land, with which you could do nothing in this direction at a moderate expense, and such land, if the rainfall is heavy, should be planted with trees.

110. The objections to steep land are its great liability to be injured by the washing effects of flowing water during heavy rain, and the consequent removal of the finer particles of the soil, and its more costly tillage.

111. Some land is met with thickly covered with stones. Those stones of course must be removed if they are of sufficient size or are sufficiently numerous to impede tillage operations. The stones may be used for making walls around the fields, for making or repairing roads or for use in building sheds, &c.

112. The most generally useful kind of land is that composed of a variety of soil materials.

113. When a soil is composed chiefly of one material, it is frequently desirable to add to it some other soil material; thus, a soil composed of clay chiefly, may be improved by a dressing of sand, and a soil composed chiefly of sand, may be benefited by a dressing of clay; but, to alter greatly the character of a soil by such means is costly. When, however, the materials needed are situated at a convenient distance, and labor is available, as it usually is in this country during the dry season, much good may be effected in improving the character of a soil, without incurring an unreasonable expenditure.

114. Land, which contains much water in a stagnant condition, is usually unfitted for profitable cultivation. Stagnant water is itself highly injurious to plants, but the evils that result from a soil containing much water, in this state, arise chiefly from the impossibility of the soil being properly aerated while the water fills its pores. You are aware that no soil can be healthy, in which the air does not circulate freely. If, therefore, you would attempt to improve a soil in this objectionable condition, you must first endeavour to remove the water, and this you can do by means of under-drainage.

115. Under-drainage may be effected by means of pipes, or broken stones buried in the soil. Trenches are first dug in the land to the depth of three or four feet, and at the bottom of the trenches the stones, or pipes, are laid and the soil is again returned into the trenches. The trenches are usually made parallel to each other at distances of from eight to fifteen yards apart, and are called parallel drains.

At right angles to the lines of these drains, and at their lower ends a somewhat deeper trench is cut, and this is also laid with pipes or broken stones, is filled up in the same way with the soil removed in cutting it; this is called the main drain.

116. The main drain is always placed where the surface of the land is lowest, and it usually terminates in an open channel or tank into which the drainage water can escape.

117. The water thus passes first into the parallel drains, and from them it enters the main drain from which it is discharged at the outfall.

118. The pipes used in drainage are made of clay, and burnt in a kiln, in the same way as roofing tiles. The diameter of the pipes used for the parallel drains varies from 1½ inches to 3 inches, and that of those used for main drains, from 3 to 6 inches. The broken stones may be any hard stones broken to a size to pass through a ring, with a diameter of 2 inches. The stones are laid in the bottom of the trench to the depth of about 1 foot.

119. Many precautions are necessary in carrying out drainage operations, the neglect of any one of which may prove fatal to the prospect of the work turning out satisfactory; however we cannot now discuss all these details, those of you interested further in this subject will find full directions in works on land-drainage.

120. Under drainage, or sub-soil drainage as it is also called, is especially useful in improving a soil that contains much salt, for instead of the salt rising

to the surface and forming an efflorescence, it passes away in the drainage water.

121. Sub-soil drainage, by removing the water below, causes the air to be drawn into the soil on the surface. A thorough circulation of air occurs in land thus drained, because each fall of rain drives out the air then in the pores of the soil, and as the water sinks down through the soil, it is followed by a fresh supply of air, which fills the pores of the soil, as they are emptied of water. Of course, the deeper the drainage is, the deeper the air goes, and consequently the deeper is the layer of the soil fitted for the wants of plants, and the further are the roots of plants removed from the injurious effects of exposure to the heat of the sun.

122. Drainage renders stiff soils more manageable and makes their cultivation less costly, chiefly by making the soil workable over a greater number of days in the year, than before. Tillage operations can always be more efficiently performed, and the qualities of a manure more perfectly utilized on a drained soil than on an undrained wet soil.

123. You may sometimes effect much good when land is water-logged, by cutting open drains for the escape of the objectionable water. An open-drain may sometimes with advantage be employed in addition to under-drains. The general use of open drains is, however, objectionable when they must occupy valuable land, as they impede tillage operations, and prevent much ground from being used; another objection is that the surface water in flowing off the land carries away much fine silt and manurial

matter. You should always endeavour to pass the rain water through the soil, as in this way the fertilizing matter it collects in its passage through the air is left in the soil as the water filters downwards.

124. Of course much land requires no artificial drainage, being provided with efficient under-drainage by natural means, that is by an open, porous, strata underlying it.

125. When land contains more than 20 per cent. of vegetable matter it is not likely to be productive. In this country, however, such land is met with but seldom, except on the tops of the higher hills. To improve this land, it is necessary to get rid of much of its vegetable matter, and this is effected, by burning the land, the fire destroys the vegetable matter, and in doing so renders its mineral matter available to plants.

126. Land in the opposite condition to that referred to in the last paragraph, is commonly met with all over this Presidency. Such land deficient in organic matter would, in the hot season, dry up rapidly and the plants growing on it would be injured or killed. The simplest, and least costly means by which you could improve such land would be by tree planting. The fall of leaves from the trees and the growth and death of forest vegetation would cause an accumulation of vegetable remains on the surface of the soil, which by partial decay would enrich the soil. The surface soil would thus be benefited not only by getting more organic matter, but it also would get more mineral matter. This mineral matter would be collected by the roots of the trees in the lower

strata of soil where they feed, and which mineral matter, rising through the tree with the sap, would be eventually deposited in the leaves, and these, on falling to the ground would, on decaying, give back the mineral matter to the soil again. You will understand that there would be no actual increase of mineral matter as regards the whole body of the soil, the increase in the percentage being confined only to the surface soil.

127. Land under tillage, deficient in organic matter, can readily be improved in this respect by ploughing in green manure, &c.

128. *Besides the means already referred to, by which land can be prepared for cultivation, there are others, but of less interest because of more limited application.* Amongst these is "warping," which consists simply of raising a soil by depositing on it naturally the silt carried by water. This practice is well understood in most parts of the Presidency. In some localities it is no unusual occurrence to have the surface of paddy land raised 2 or 3 inches in height by "warping" in a single year.

129. There is of course much land which cannot be fitted for cultivation, excepting by incurring an expense far beyond the possible value of the land when reclaimed, and there is some land which never can be fitted for cultivation.

III. Tillage Implements and Tillage Operations.

130. The varieties of tillage implements used by the husbandman in this country are but few ; this

must be attributed chiefly to the low state of agriculture generally.

131. By some it is asserted that the cheapness and abundance of labor in this Presidency explains the poverty of our agriculture in implements of the varieties met with in other countries. There can be no doubt but that cheap labor when available at all seasons of the year does obviate to some extent the use of labor-saving tools. But in some parts of the Presidency the price of labor is more than 50 per cent. higher than in other parts, and yet we find that in spite of the higher price of labor the same rude implements are in use there as where the price of labor is low. And further, though the price of field-labor has increased fully 50 per cent. during the past 30 years, no change whatever has taken place in the number of the varieties, or in the construction of the implements of our husbandry.

132. It is also said that the costliness and the general large size of the implements of modern agriculture are other reasons why they have not been acceptable to the cultivators of this country. There is some force in these objections. The manufacturers of implements in more advanced countries cannot appreciate the backward condition and the actual circumstances of Indian agriculture.

133. There are, however, many improved implements which might be largely used in India, even on small holdings. Small farming is not confined to India. In Belgium, where the average size of a farm differs but little from that of the farms of this Presidency, many of the smaller implements of

modern agriculture are in regular use; and the same may be stated regarding a large part of Ireland, also a country of small farms.

134. There is, it is to be feared, but little prospect of anything of a really satisfactory nature being achieved, in the introduction into general use of improved implements in this country, until agricultural education, following in the foot-steps of general education, has first prepared the way. The uneducated and superstitious cultivators or laborers will recognize no merit in an implement which was either quite unknown to, or unused by, their forefathers, and of course, when such implements are placed for trial in the hands of such people, they can readily show that the improved implements are unlikely to prove successes with them. A certain amount of intelligent appreciation is necessary on the part of the workman, who first uses the new or improved implement, and if this is absent and positive hostility be present in its place, while the employers of the laborers are either as hostile or are apathetic, it is not surprising that the difficulties encountered should be great in such efforts.

135. The implements used generally in agriculture are the plough, the harrow and the roller. The employment of all three implements is usually necessary in order to bring the soil into a proper state of tilth, eradicate the weeds and prepare a suitable seed-bed.

136. Even though labor may be abundant and cheap, you cannot turn over the soil by manual labor, by means of mamooties or spades, at the

low cost at which it can be done by an improved plough.

137. A cooly working in the ordinary way will, in a day, dig over only about 600 cubic feet of earth; *his pay would be three annas, and you would* thus get 200 cubic feet of soil turned over at the cost of one anna.

138. An improved plough with a pair of cattle and a driver will cost thirteen annas per day. The plough would readily plough three-fourths of an acre of land to a depth of 7 inches in a day; this would be 19,056 cubic feet of earth turned over by the plough, or 1,465 cubic feet turned over at the cost of one anna.

139. We thus find that, the plough could perform *the work of turning over the soil at about one-*seventh the expense at which the work could be done by laborers *working with mamooties* or spades.

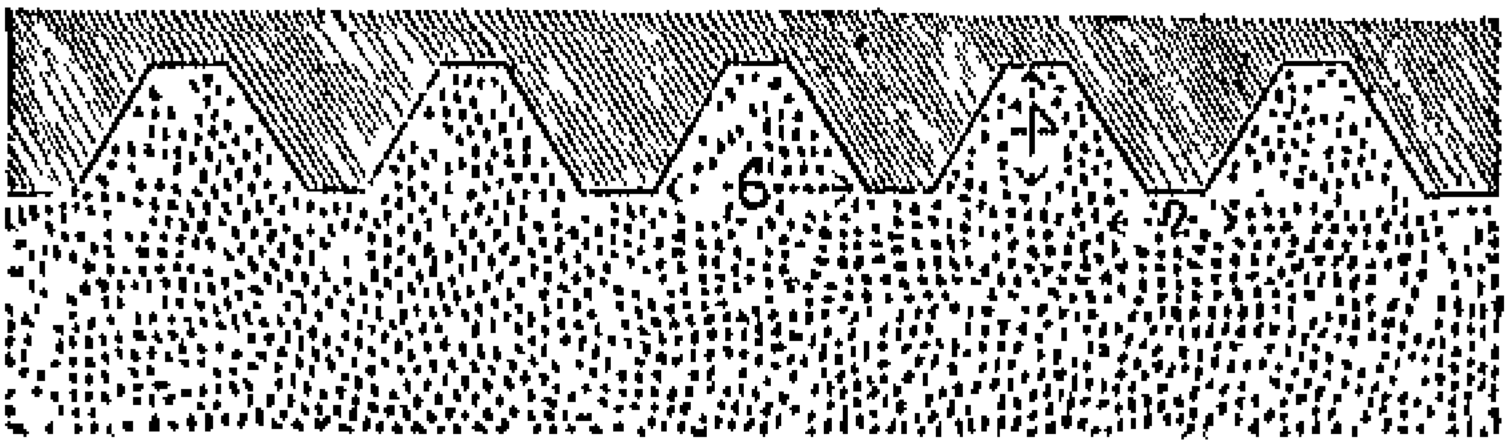
140. But it is not only in the lesser cost of turning over the soil that the advantage of using such a plough consists, but, in the better control the owner of the plough has over his land: he, with one man, may plough daily half an acre of his holding, whereas the man, who is dependent on manual labor for turning over his soil, must employ daily at least 20 laborers to effect the same work. Now, as you know, if a great number of cultivators were thus dependent on manual labor, for the tillage of *their soils, the work of tillage would, in some places,* progress very slowly, and the total amount of work done in a season would be very small while the cost would be excessive.

141. Experience in all countries has conclusively shown the superiority of the plough for effecting the tillage of the soil.

142. From time immemorial a plough of some kind has been used by the husbandman. It is true that up to a comparatively recent period the so-called plough was, in most countries, little more than a crooked branch with a hardened point, by which the soil was scratched. Monumental tablets of very great antiquity represent the plough exactly as we now *meet* with it in most parts of India. In all countries this form of plough appears to have, at one time, been in general use; but, whereas other countries under the influences of a progressive civilization have discarded this rude form of implement as perfectly unsuited to the requirements of agriculture in the present day, India with one or two other countries has remained behind and still uses the ploughs of antiquity.

143. The ordinary plough of this country does not turn over the soil, and therefore, as we understand the term ploughing in more civilized countries, the operation performed by the native implement cannot be termed ploughing. The work done is that usually performed by a cultivator, which stirs, loosens, and mingles the particles of the soil together, but does not raise the soil bodily and invert it as a plough does.

144. The section of the trench, or furrow, made by the so-called native plough in its passage through the soil is in form like the letter V as shown on the next page.



In this section, the shaded portion represents the soil that is moved when the land is once ploughed by the native plough.

The work performed by the plough is much less than it appears to be to a casual observer, for in reality less than one-half of the under soil is moved when the plough passes only once over the field. This fact is well known to cultivators who, endeavour to remove the ribs of unstirred soil by ploughing the field several times, and in different directions.

145. Up to about the beginning of the present century, the plough used even in advanced countries was a very clumsy, inefficient implement, constructed chiefly of wood. Of late years however, the construction of ploughs has received great attention, from men well acquainted with mechanical principles, and the result of their investigations has been the production of a plough well suited in every respect to the requirements of modern agriculture.

146. As our soils and crops have such varying requirements, it has been found economical to provide special kinds of ploughs for special work; hence we have sub-soil ploughs, trench-ploughs, wheel-ploughs, swing-ploughs, turn-wrest ploughs, double

mould-board ploughs, &c., &c., while of each variety there are many sub-varieties.

147. There can be no doubt whatever but that certain operations in ploughing are performed most efficiently and economically by ploughs specially adapted for such work, and, when the area of the farm is large, it is always well to employ ploughs of different kinds, adapted to the varying requirements of the farm. However, on small holdings this cannot be done, and the small farmer must content himself with a plough designed for doing general work.

148. In selecting a plough you should endeavour to procure one that is not too heavy, and is at the same time sufficiently strong to withstand the effects of exposure to the weather, and a good deal of ill usage. You must remember that a plough costing twenty-five rupees may be over a term of years a much cheaper and a more desirable implement to possess, than one of which the first cost may have been under five rupees. Remember always that it is the cost of the work done by an implement you should inquire into, rather than confine your inquiries to the cost of the implement.

149. We speak of the furrow-side and the land-side of a plough. When the plough is at work the furrow-side is the part of the plough nearest to the ploughed land, and the land-side is the part near the firm or unploughed soil. If we stand, and look at a plough on its furrow-side, we observe the following parts:—

(*a*). *Share*—This occupies the front of the portion of the plough that rests on the ground. The share has a most important function to perform. Its action is that of a spade pushed horizontally, the cutting edge of which has been slanted to facilitate its insertion into the ground. The share is the first portion of the plough which enters the soil, which it cuts horizontally.

(*b*). *Mould-Board.*—This is also called the breast or turn-furrow, because it is through its agency that the soil or furrow-slice is turned over. The soil after passing over the share is received by the mould-board, which raises it gradually, turns it over and finally deposits or moulds it in the way required. The mould-board is connected with the share of which, to the ordinary observer, it seems a part.

(*c*). *Coulter.*—This is the bar of iron in the form of a knife which at its lower end you observe is near the point of the share. The coulter is intended to cut the soil vertically, at right angles to the cut made by the share.

150. The three parts of the plough just referred to, the share, mould-board and coulter, are its most important working parts. The other portions of the plough are intended merely to facilitate the efficient working of these parts.

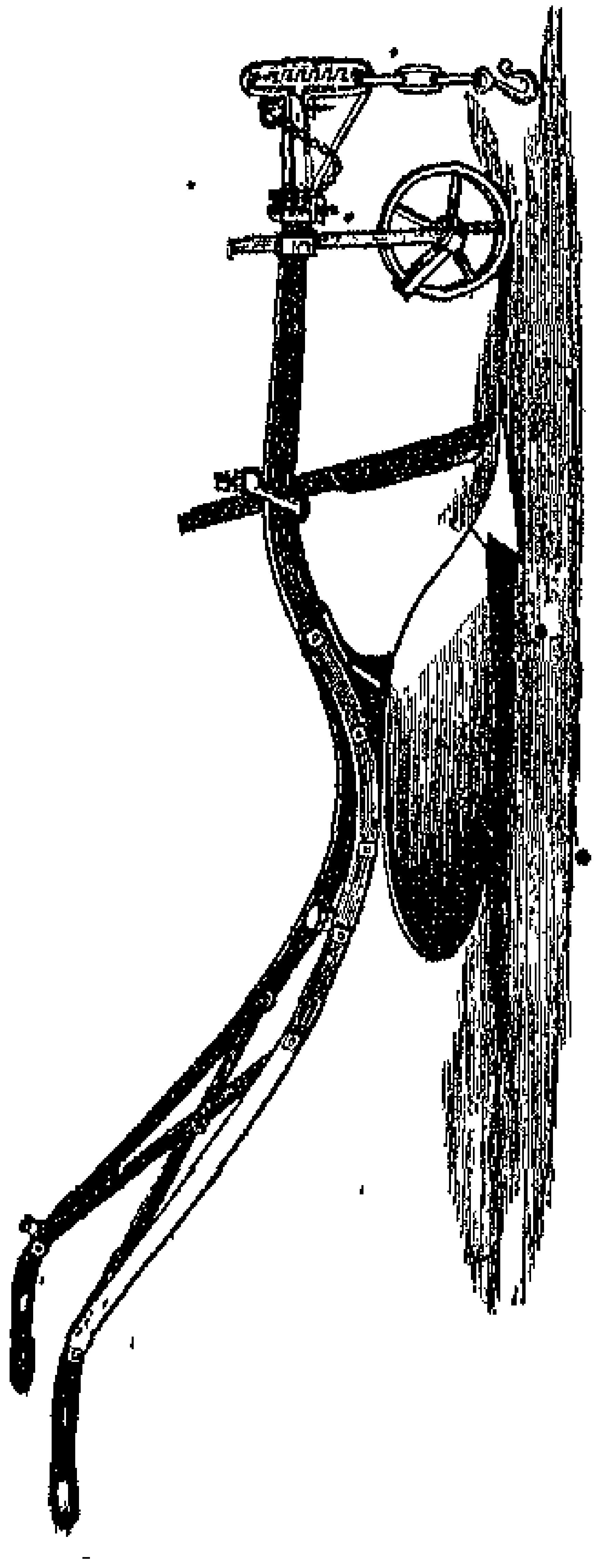
(*d*). *Stilts.*—These are connected with the handles by which the ploughman guides, steadies and partly regulates the work of the plough.

(e). *Beam.*—This is a slightly curved bar of iron to which the coulter is fixed, and to which the stilts and mould-board are joined, and to the extremity of which the cattle are attached when the plough is at work.

(*f*). *Bridle.*—This is fixed on the end of the beam, and to it the cattle are yoked. By means of this bridle you can regulate the depth and width of the furrow-slice, that is, the earth moved by the plough. If you raise the draught chain on the vertical part of the bridle you make the plough go deeper; if you lower it the ploughing will be more shallow. If, on the horizontal part, you place the draught chain to the right, that is, more to the furrow-side you make the plough cut a wider furrow; if you place it to the left, the furrow-slice is made narrower.

(*g*). *Wheel.*—The wheel, as you will see, supports the front part of the plough. It is of use in moving the plough over the farm. But its chief use is to regulate the depth of the ploughing. If the wheel is put down very low the ploughing is shallow; if the wheel is raised the plough goes deeper. Sometimes two wheels are used, one called the furrow-wheel, and the other the land-wheel. When two wheels are used the width of the furrow as well as its depth can be regulated.

IMPROVED PLOUGH.



151. You have already been reminded that it is the cost of the work performed by an implement, rather than the cost of the implement, usually requires consideration.

152. An ordinary native plough will usually cost less than five rupees, while a European plough may cost twenty-five rupees. At first sight, the native plough possesses apparently a great advantage over the improved plough, but let us consider whether this is really so. You know that the section of the furrow *of a native plough is V-shaped. Now, the test of* the working capabilities of a plough is the amount of soil it is capable of turning over in a given time at a given cost. When a native plough is working under favorable conditions the section of the furrow it makes may be taken as 5 inches wide at the top, one inch wide below, and 5 inches in depth, and the area of the section will be 15 square inches. If the width of the furrow at the surface of the ground is 5 inches, the plough in going over an acre in this way must travel nearly 20 miles. But remember that, in one operation, only half of the land is moved at the outside, there being ribs of unmoved earth left between each furrow. To stir those also, the plough must again pass over the land in a direction at right angles to the line of the first ploughing, thus travelling other 20 miles; thus we have 40 miles passed over in ploughing one acre to a depth of 5 inches, some portion of which still remains unstirred. But even granting that in two operations the whole of the soil can be stirred to a depth of 5 inches, the total quantity of earth moved

per acre would be only 672 cubic yards and this, remember, by the employment of 3 pairs of country cattle, 3 ploughs and 3 drivers; for, under average circumstances, a pair of country plough cattle will not travel more than 13, or 14 miles per day in ploughing.

153. Now, to arrive at the cost of ploughing the acre by the native ploughs, we may calculate as follows:—

	RS.	A.	P.
3 pairs of country cattle at 6 annas per pair per day	1	2	0
3 drivers at 3 annas per day	0	9	0
Wear and tear of ploughs	0	1	0
Total ..	1	12	0

This would represent 384 cubic yards of earth turned at a cost of one rupee.

154. A European plough, in ploughing, cuts a rectangular shaped furrow. In ordinary ploughing, the furrow measures 9 inches wide and 7 inches deep, and the section has thus an area of 63 square inches against 15 square inches, the area of the section of the furrow of the country plough. A fair day's work for a European plough is three-fourths of an acre ploughed. To effect this, the cattle must travel about 8 miles excluding turnings at the headlands, and the quantity of earth turned over will be nearly 705 cubic yards, against 672 cubic yards ploughed in one day by three country ploughs. To calculate the

cost of ploughing an acre by the European plough we may proceed as follows :—

	RS.	A.	P.
Hire of 1 pair of cattle for 1⅓ days at 8 annas per day	0	10	8
Hire of 1 driver for 1⅓ days at 3 annas per day	0	4	0
Interest, wear and tear of plough (assuming that the plough will last 8 years charging repairs at Rupees 2-8-0 per annum; interest at 5 per cent. chargeable over 40 acres ploughed in the year) for 1⅓ days, at Rupees 0-2-9 per day	0	3	8
Total ..	1	2	4

In ploughing an acre we get 941 cubic yards of soil raised and turned over most efficiently at a cost of Rupees 1-2-4, or at the rate of 821 cubic yards per rupee, against 384 cubic yards per rupee when country ploughs are used.

155. It is true that a very considerable number of the cultivators of this Presidency could not raise even 25 rupees to buy a plough, yet there are thousands of them who can easily provide the money. And it must be remembered always that, to do the same work by native ploughs as can be done by a European plough, you require three of the former with three pairs of cattle and three drivers. The man who buys a European plough *can readily procure* the money needed by selling a pair of his cattle. It is true, that he would frequently require for the European plough a larger and a better fed pair of

cattle, than those usually used; but then, there is a still further saving, in wages and cattle-keep in favor of the investment.

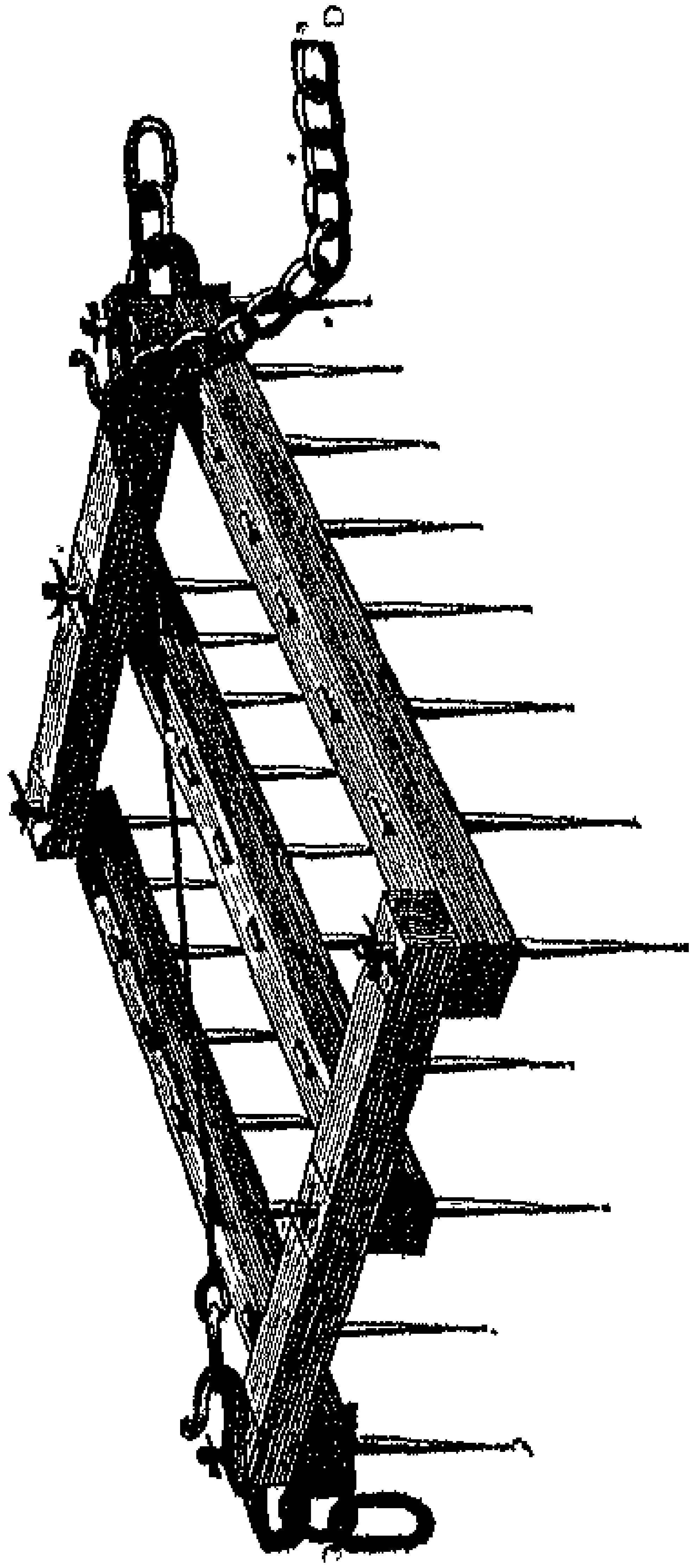
156. The harrow varies greatly in form according to the kind of work for which it is intended. An ordinary harrow consists of a frame made of wood or iron in which a number of pointed pieces of iron are fixed. These pieces of iron are called the tines or teeth of the harrow; they are placed at equal distances in the frame of the harrow and, so that one may not follow another on the same line and in this way the surface of the ground is uniformly operated on.

157. Harrows are employed for cleaning the land of the roots of weeds, for pulverizing the soil, for covering newly-sown seed, and for opening up the surface of the soil when it has become caked over. The following drawing represents an ordinary wooden harrow with iron teeth (*see page* 50).

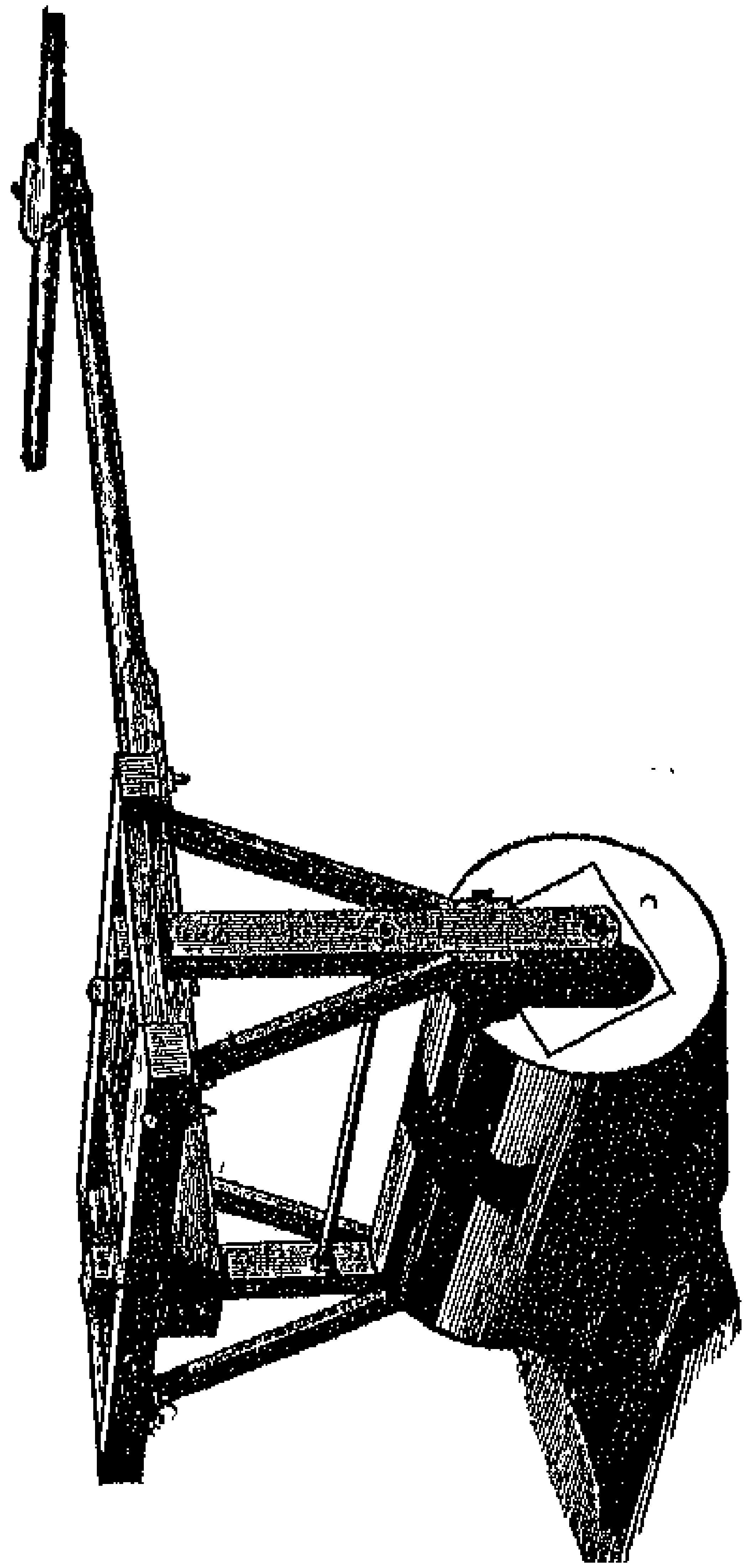
158. The roller consists of a cylinder of wood, of stone, or of iron, which is fixed in a frame, in a way to admit of its revolving freely over the ground; to the frame is attached the pole or shafts for the draught cattle.

159. For general use, a wooden roller suffices; and such a roller can readily be made by any village carpenter. The following drawing (*see page* 51) represents a wooden roller.

160. The roller is intended to crush or pulverize clods and to consolidate the soil. It is also used to smooth the surface of land for seed.



THE ROLLER.



161. When the clods are broken down, a much larger portion of soil is exposed to the beneficial effects of the air, and consequently more plant-food becomes available to the crop growing on the land. When the land is consolidated by passing a light roller over it, evaporation is checked and a larger quantity of moisture is thereby retained.

162. The constituents of a soil exist in different states, thus, a portion of them are soluble in water, and are therefore immediately available as the food of plants; another portion not soluble in water, but soluble in acid, are gradually becoming available to plants as food, while the remainder exist in a passive state.

163. In this way we may classify the constituents of a soil as first, active, that is those portions soluble in water; second, dormant, that is those portions which are insoluble in water, but soluble in acid; and, third, passive, those portions which are soluble neither in water nor in acid.

164. The fertility of a soil depends upon the proportion of active and dormant ingredients present in it. These together seldom form more than 10 per cent. of the entire weight of the soil of which the active constituents form an exceedingly small proportion. We must not consider the passive constituents of the soil as valueless, for, on the other hand, they constitute the great store out of which, in course of time, the soil is provided with dormant and active constituents.

165. The crops we produce take up the active or available food the soil contains, and which, of course, becomes thereby diminished in the soil. This loss is usually partially or entirely made up by the application of manure, but it is to some extent compensated for, by the gradual change of the dormant ingredients *into active ingredients; the diminished quantity of* dormant ingredients being in turn replaced by a portion of the previously passive ingredients entering the dormant state. These changes are constantly going on, the dormant ingredients becoming active and the passive dormant, and, it is to facilitate and expedite these changes, that we perform many of our tillage operations.

IV.—Manures, Irrigation, &c.

166. Plants consist of two principal parts, one which burns away called organic, and the incombustible part or ash that remains after burning called inorganic.

167. The ash of a dry plant varies from 2 to 7 per cent. of its entire weight; this ash is the mineral food removed from the soil during the growth of the plant.

168. A knowledge of the composition of these ashes will enable us to determine the mineral food of the plant. This mineral food is as essential to the growth of the plant as the gaseous food it obtains.

169. By making numerous analyses of plants, it has been found that certain orders of plants take up a particular kind of mineral food; thus, in the ashes of plants of the cereal order, silica is the predominating ingredient, while in those of the plants of the leguminous order, lime is the chief ingredient. It has been found that in whatever kind of soil a leguminous plant is produced, the chief portion of the ashes of that plant will always be lime.

170. The more fertile a soil is, and the better it is cultivated, the more mineral food will the plant take up, and the more valuable will be the produce raised.

171. If you grow several crops on a piece of land, without applying any manure to it, the land will gradually become poorer in the special mineral matters on which this particular crop feeds, until eventually a good crop cannot be raised on the land.

172. Food is required as much by plants as by animals. The food of plants is obtained from the air as well as from the soil. It is partly liquid, and partly gaseous, but never solid. In the water taken up by the roots, there are nearly always some gaseous and mineral matters dissolved. The atmosphere supplies plants with carbonic acid gas and watery vapor, but from the soil also these are obtained by the plant.

173. Manures act either by supplying plant-food to the soil or by rendering accessible to plants, food which was previously in the soil, but in a form in which it could not be immediately used by plants.

174. The term manure is applied to any mineral, vegetable, or animal substance, capable of increasing the producing-powers of a soil.

175. The most common, and most generally useful of all manures, is that known as farm manure. When properly made, farm manure should consist of the litter, *i.e.*, straw, leaves, husks, and other *vegetable refuse, used for bedding stock, and the* solid and liquid excrements of the animals. Such manure should contain most of the mineral matter *removed in the crops produced on the farm, for the* largest portion of the mineral matter of a plant is found in those parts of it, which are not usually marketed, and which are generally treated as refuse.

176. It is a very wasteful practice to throw farm manure into a heap out-of-doors, where it is liable to be washed by every shower of rain, for the valuable portions are soluble in water, and therefore easily washed out of the manure.

177. Farm manure is also very liable to be injured, if not stored properly; thus, if it is simply thrown loosely into a heap, decomposition will set in rapidly, and a considerable proportion of the manure will assume a gaseous form, and be lost. Farm manure should in this country be kept under a roof, until it is required for use, and it should be in as compact a state as possible, to prevent air getting too freely amongst it. When so stored there need be no appreciable loss of its fertilizing matters.

178. In order to get good farm manure, it is well to have the floor of your cattle-shed sunk about two feet below the surface of the surrounding ground,

and to throw into this pit daily, sufficient waste vegetable refuse, to keep your stock comfortably bedded. This bedding will absorb the urine of the cattle, which generally is wasted, and which is a most valuable fertilizer. You must give enough bedding to cover the solid excrements, but you should not give too much, or the quality of the manure will suffer.

179. The value of cattle dung as manure, is recognized everywhere in this country, but there appears to be but little known, regarding the very close connection there is between the fertilizing value of cattle dung and the quality of the food, on which the animals that made the manure were fed.

180. When cattle are full grown, are not overworked, and get a sufficiency of good food, their dung and urine are rich in fertilizing matters.

181. The excrements of young stock are not so valuable as those of animals fully grown, and similarly fed, because the younger animals need to take from their food the materials required to support their growth, hence the wastage or excrements possess a proportionally less value. Again, a cow in calf or a milch cow makes a fuller use of the food consumed, than cows that are not in calf or not yielding milk, and in the same way a working bullock yields a poorer manure, than a bullock which is unemployed and similarly fed.

182. Farm manure is a generally useful fertilizer, because when well prepared it contains most of the plant-food removed from the soil by the crops. It usually contains phosphoric acid, potash, and nitro-

gen, all costly and important plant-foods. Though the phosphoric acid and potash will not assume a gaseous form, they are very soluble and readily washed away. *The nitrogen, on the other hand,* quickly assumes a gaseous form if the air has too free access to the manure.

183. The general use in this country of cattle dung as fuel is greatly to be deplored, not only because of the direct loss of manural matters that result,—the ashes of the dung are seldom used as manure,—but because of the indirect losses of manural matters that arise from the practice. When cattle dung is collected for use as fuel, *the liquid excrements are entirely wasted.* If every ryot would grow live fences of a suitable kind, or a few fuel trees on his holding, which he could readily do without incurring any money outlay, there would be no excuse whatever for continuing to use cattle dung as fuel.

184. Though in most parts of this Presidency bones can readily be obtained at a very moderate cost, and *though there is no manure which is more required* by the soils of this Presidency, there is perhaps not a single ryot who uses bones in manuring his land.

185. If you remember that the bones of animals are formed directly from materials furnished by the plants consumed by the animals, and that the plants obtained the bone material from the soil, you cannot fail in understanding how it is that a soil becomes impoverished in the minerals which afford bone material. Every animal reared represents a certain quantity of bone material removed from the soil which afforded the food of that animal.

186. If many generations of animals are bred and reared in a certain tract of country, the soils of that country which afforded the food of the animals must necessarily be becoming poorer and poorer in bone-forming minerals, and as a natural consequence the stock from getting less of this bone-material in their food, will gradually degenerate, and become of smaller size. The same applies with equal force to man, who is as dependent on the earth for the materials for building up the bony frame-work of his body. You must, therefore, apply bones in manuring your land, both arable and pasture.

187. Bones may be applied to the soil either coarsely broken or reduced to a powder, the finer they are pulverized the more speedily they decay. Or the bones may be placed in a pit with farm manure, in which, if the manure is occasionally moistened by pouring urine over it, the bones will quickly decay.

188. In European and other countries bones are prepared for the soil by exposing them to the action of sulphuric acid, the product obtained being called superphosphate. The action of this manure is much more energetic than that of bones in any other form.

189. Lime (carbonate of lime) is largely used as manure in other countries, but in this country it is never so used by the cultivator.

190. Lime is available in this country in the form of shells, as well as in nodules and in rocks.

191. In whatever form the lime is met with originally, it must be burned or calcined before it can be used as manure. Burnt lime, after being

slacked with water, assumes a powdery form in which state it can readily be distributed over the land. However, when first slacked the lime is too caustic in its action, and it should therefore, as a rule, not be applied to the soil until it has for a time been freely exposed to the atmosphere, when it loses its caustic character.

192. Lime acts on the organic matter in the soil, as well as on the inert mineral matters, rendering plant-food available. All crops take up lime. Some orders of plants consume considerable quantities.

193. The costliness of lime in this country, owing to the dearth of cheap fuel, is a great detriment to the more general use of this mineral. However, as long as agriculture is practised as at present, there are perhaps no grounds for much regret that lime should be too expensive to be used by our ordinary cultivators, for, if they used lime and starve their land as regards manure, as they now do, the use of lime would increase the exhaustion of their already impoverished soils.

194. If you remember that the fertilizing value of an excrementitious manure depends greatly upon the food consumed by the animals which furnish the manure, you will readily understand that, as so much of the farm produce of this country is consumed by the people, necessarily their excreta must represent a considerable value;, yet, except near two or three large towns human excreta, neither liquid nor solid, are used in agriculture.

195. In some countries agriculture depends greatly for manure on human excreta. When it is con-

conveys to the crop plant-food in solution or in suspension.

204. A piece of land which is under irrigation by water, which brings plant-food, may be cropped without manure for a long period of time, without showing any sign of exhaustion, if the plant-food is of the kind required by the crop.

205. When plant-food is in solution in irrigation water, the water is clear and bright. When the food is suspended in the water, the water is discolored, *and does not become clear, until the earthy particles which were in suspension become deposited in the form of silt.*

206. You must not assume, then, because the water is clear and bright that it does not contain plant-food. Some clear waters are used with good effect in irrigation. However, generally, it is the rivers which convey suspended matter that are most highly valued for irrigation. This suspended matter is washed off the higher land during heavy showers of rain. When water with this suspended matter is used in irrigating land, this suspended matter is left on the land as silt, and enriches the soil.

207. When clear water that contains nothing but gaseous matter in solution is used in irrigation the *action of that water is to render soluble the plant-food the soil previously contained. A piece of land thus irrigated would yield a larger crop under the* irrigation simply at the expense of the land itself, and unless manured its fertility would gradually become diminished, and the more quickly on account of the stimulating action of the irrigation water.

208. There is in this country an enormous waste of irrigation water. It has been calculated that, were the water now available used only in sufficient quantity for the requirements of the crops produced, the area of land benefiting from irrigation in this Presidency might be doubled.

209. Again, if, instead of growing so much paddy, our cultivators could be induced to grow crops of a less aquatic character, there might be a great addition to the area of land benefiting from irrigation, and the country correspondingly protected from the devastating influences of famine.

210. When irrigation water contains large quantities of silt, and it is an aim of the cultivator to secure this silt, it may suit his ends to use the water in the lavish way now so common; but in a country now so liable to suffer from famine as this is, it is a grievous thing, that any cultivator should have it in his power thus to abuse for his personal gain a boon which should be used so as to produce the best effects on the country generally. At any rate, if such a practice is deemed admissible, the cultivator so using the water should pay for the full value of the water.

211. When irrigation water is used as it ought to be in a country where it is so precious as regards the interests of the people generally, it should be passed through the land rather than simply over it.

V.—Farm Crops.

212. The majority of our farm crops are propagated by seed. It is very important that good fresh

seed should always be selected, and that it should always be free from admixture with other kinds of seed. Old and mouldy seed is especially to be avoided. *Some seeds retain their vitality for five or six years,* but usually it is unwise to sow seed which is more than two years old. As a general rule, the larger kinds of seed sink in water when they are fresh and good.

213. To obtain the best results from seed, great care should be exercised in preparing the land for it. The seed should be sown at the right season, and should be deposited in the ground at the proper depth, and in the right quantity. When seeds are sown too shallow, the roots of the plants they produce *are too near the surface of the ground, and in dry* weather the plants suffer. On the other hand, if the seed is buried too deep in the ground, much of it will fail to germinate. While if the ground is too thickly sown with seed too many plants are produced and they cannot all get sufficient nutriment from the soil, hence many become sickly and unproductive. There is a great difference as to the depth at which different seeds may be sown. Some may be sown at a depth of four inches, while some give the best results when sown at only half an inch in depth.

214. *Other crops are propagated by division, by* taking offsets, by dividing the roots, by suckers, by layers, by cuttings, by grafting, and by budding; in grafting and in budding a portion of one plant is made to unite with a growing plant of the same species. In the other ways of propagating by division, the portion of the plant to be multiplied is

rooted at once in the ground. Varieties are usually propagated by division only.

215. As has been noticed, plants consist of two *chief parts, one called the organic, and the other* inorganic. Of the fresh plant, the chief part is water. Of the dry plant, woody fibre forms the chief part, and is composed largely of carbon derived from the carbonic acid taken from the air. Nearly one half of the weight of woody fibre is carbon.

216. The other organic substances of the plant consist of starch, oil, sugar, gum, gluten, &c., all of which, excepting the last mentioned, are composed of carbon, hydrogen, and oxygen, and are called non-nitrogenous substances. Starch forms the chief part of rice, maize, and other grains, and is the chief constituent of many kinds of roots, tubers, &c.

217. Oil or fat is found most largely in seeds and grains. Some seeds, the oil seeds for instance, contain a large quantity of oil.

218. Sugar is present in the juice of most plants when approaching maturity. In some plants, for instance the sugarcane, the sweet sorghum, the beet-root, and others, sugar is present in such quantities as to repay the cost of its extraction.

219. Gum and mucilage are present in the stems of many oil-producing plants, and they are always found in considerable quantities in oil seeds.

220. Gluten is formed of oxygen, carbon, hydrogen, and nitrogen, with some sulphur and phosphorus. It is a sticky substance found in the grain of wheat, and in other cereals, and resembles in composition the fibrine of flesh, hence its nutritious properties.

221. We have already referred to the mineral constituents of plants in referring to manures.

222. When a seed is deposited in the ground under favorable conditions, it absorbs moisture, swells and sends a shoot or stem upwards and a root downwards; while these organs are being formed, the young plant has to depend entirely on the nutriment stored in the seed, but it maintains itself long before the seed is exhausted.

223. Plants obtain their food partly from the air and partly from the soil. The former is taken up by their leaves and the latter by their roots. From the air, plants obtain carbonic acid, ammonia, nitric acid, and watery vapor. Though free nitrogen forms four-fifths of the bulk of the atmosphere, it is not appropriated by plants.

224. The food of plants is always in the liquid or gaseous form. No solid food is taken up by plants. The water containing the soluble food of the plant enters the roots and then passes up through the plant until it reaches the leaves, through which most of the water is exhaled into the air, the food being retained by the plant.

225. During night, plants absorb oxygen and give off carbonic acid. Though the quantity of carbonic acid in the air is very small, it nevertheless suffices for the greater part of the wants of most plants. By thus removing the carbonic acid, plants purify the air. Animals breathe in pure air and respire the nitrogen along with carbonic acid. This carbonic acid being highly injurious to animals, it will be

seen how beneficial is the action of the plant in removing carbonic acid from the air.

226. *Experience has shown that certain constituents of the soil are exhausted sooner than others,* if the soil is made to produce one description of crop too frequently, and it has been found that plants of different tribes and families, greatly differ in their demand on the soil for food. Some take up much potash, others much lime, and others much phosphoric acid, &c.; while the roots of some plants feed in the upper layer of soil, and those of others deep down in the soil Again, if one variety of plant is grown too frequently on a piece of land, the land becomes infested with insects of the kind, which preys on that particular kind of crop. Some plants grow luxuriantly and cover the ground, thus killing down the weeds, while others produce only a scanty vegetable growth and encourage *rather than* check the growth of weeds. Some crops are usually removed *entirely from the farm,* while *other crops are consumed* on the farm by the stock, and thus aid in providing the farm with manure. Some plants have fleshy fibrous roots, in which much plant-food is stored, these on the removal of the crop decay and afford plant nutriment. Further, the period of growth of different crops varies considerably, it is therefore an advantage sometimes to change the crop in order to facilitate the tillage of the land at certain seasons of the year, or to extend the period over which tillage can be performed. For these and other reasons, then, it has been found desirable to adopt rotations, in cropping land, that is to prescribe series of crops for given periods of time.

227. The following is a useful rotation for a loamy soil:—

1st year—Maize and cotton manured.
2nd year—Indigo.
3rd year—Cholum, followed by gram as a summer crop.
4th year—Guinea-grass—mown—manured.
5th year—Guinea-grass—grazed.

228. Other rotations may be adopted according to the wishes or requirements of the husbandman. No rotation can be drawn up that would be suited for general adoption in South India, as the soils differ so greatly and the crops grown are so varied.

229. The following statement shows the area of land annually under the different classes of crops grown in this Presidency:—

—	Acres.	Per cent. of whole area under crop.
Corn crops	20,264,000	83·5
Oil seeds	1,197,000	4·9
Special crops	1,827,000	7·5
Garden crops	439,000	1·8
Topes	538,000	2·3
Total ..	24,265,000	100·0

230. The next statement shows the area of land under the different classes of crops in England annually:—

Corn crops	7,285,052
Green crops	5,611,005
Pasture	10,088,029
	23,586,186

231. On comparing those statements it will be seen that the demand made on the soils of Madras is much greater than that made on the soils of England, thus while the latter are only called upon to produce corn crops on 30 per cent. of their entire area, in Madras 83 per cent. of the area of the cropped land is called upon to yield corn crops.

232. *On comparing the statements further,* we observe that neither green crops nor pasturage occupy any appreciable portion of the cropped area in Madras, while in England such crops constitute 70 per cent. of the crops grown. Green crops and pasturage are looked upon by the agriculturist as restorative crops, because they are as a rule consumed on the farm by stock, the excrements of which the farm gets for manure.

233. Corn crops are usually sold away from the farm, excepting the straw, and therefore such crops represent much fertilizing matter lost to the farm. These crops are therefore termed exhaustive crops.

234. *It is not surprising that the average yield of* the corn crops of this Presidency should be less than half the average yield of such crops in England, where, for every acre under an exhaustive crop two acres of restorative crops are grown.

235. Under good management many crops classed as exhaustive may be made restorative; thus, in the case of the indigo crop for instance, of which all we require for sale is the dye, but which as usually managed is an exhaustive crop from the whole of the indigo plant being removed from the farm, all

that would be necessary would be that the plant after the extraction of the dye, should be returned to the soil. Again, in the case of the cotton crop the lint is the valuable product, and if this only was sold away from the farm, and the seed used in feeding the stock of the farm, while the plant was decomposed in the manure heap, the cotton crop would not be an exhaustive one.

236. The following crops are produced in this Presidency :—

Cereal Crops.

English or Trade Name.	Scientific Name.
Ragi	Eleusine coracana.
Paddy	Oryza sativa.
Varagu	Panicum miliaceum.
Millet	Panicum miliare.
Cumboo	Penicillaria spicata.
Italian Millet	Panicum italicum.
Great Millet	Sorghum vulgare.
Wheat	Triticum vulgare.
Maize or Indian Corn ..	Zea Mays.

Pulse Crops.

Ground-nut	Arachis hypogæa.
Dholl or redgram ..	Cajanus indicus.
Bengal-gram	Cicer arietinum.
Horse-gram	Dolichos uniflorus.
Black-gram	Phaseolus radiatus.
Green-gram	Phaseolus mungo.
Peas, garden pea	Pisum sativum.

Oil Seed Crops.

Ground-nut	Arachis hypogæa.
Rape seed	Brassica napus.
Hemp seed	Cannabis sativa.
Linseed	Linum usitatissimum.
Castor seed	Ricinus communis.
Lamp oil seed	Do.
Gingelly seed	Sesamum indicum.

Fibre Crops.

Hemp	Cannabis sativa.
Jute	Corchorus capsularis.
Sunn hemp	Crotalaria juncea.
Cotton	Gossypium indicum.
Roselle	Hibiscus subdariffa.
Flax	Linum usitatissimum.
Rhea	Bœhmeria nivea.

Dye Crops.

Safflower	Carthamus tinctorius.
Turmeric	Curcuma longa.
Indigo	Indigofera tinctoria.
Chayroot	Hedyotis umbellata.

Miscellaneous Crops.

Sugarcane	*Saccharum officinarum.*
Chillies	Capsicum annuum.
Coffee	Coffea arabica.
Tea	Thea assamica.
Cinchona	Cinchona (var.)
Potatoes	Solanum tuberosum.
Tobacco	Nicotiana tabacum.
Plantain	Musa paradisiaca.
Onions	Allium cepa.
Garlic	Do. sativa.
Fenugreek	Trigonella Fœnum Græcum.
Coriander	Coriandrum sativum.
Green ginger	Zingiber officinale.
Cummin seed	Cuminum cyminum.
Pepper	Piper nigrum.
Mustard seed	Sinapsis ramosa.

VI.—Farm Stock.

237. In this Presidency no horses or mules are used in agriculture, and no pigs are reared, or are fed by farmers, thus the farm stock consists of only cattle, sheep, and goats.

238. We have in this Presidency 8¼ million head of cattle; and of goats and sheep 6¾ millions. The average weight of a bullock, and of a sheep or goat, as counted, cannot be estimated higher than, the former 240 lb and the latter 30 lb. live-weight. Or, we may estimate that 8 sheep or goats will weigh about the weight of one bullock. It must be remembered that when the farm stock were counted, the calves were reckoned as cattle and the lambs and kids as sheep.

239. For convenience of comparison, we may calculate the sheep as cattle by dividing the 6¾ millions by 8 which gives us 843,125 as the number of cattle the sheep represent, which added to the 8,270,000 head of cattle gives a total of 9,113,125 head of cattle.

240. We have in this Presidency 87,500 square miles of Government land; there are thus 104 cattle, each of 240 lb., per square mile of country. Computing the live stock of other countries in the same way, we find that Belgium possesses 569 head per square mile, Great Britain 498, Bavaria 427, and France 362.

241. There can be no doubt whatever but that the more abundant are the cattle in a district, the more flourishing will be the state of agriculture in that district.

242. The cattle of this Presidency, like those of India generally, belong to the species termed *Bos Indicus*. The cattle of this species are distinguished by their humps, high withers, long pendant ears, large pendulous dewlap falling in folds, irregular formed back rising at the hips and falling suddenly at the tail, and by the peculiar sound of their voice and by their color.

243. There are several varieties of cattle in Southern India; the most important of which are the Nellore and the Mysore.

244. The Nellore breed is met with chiefly in the district from which the breed takes its name. Cattle of this breed are large but they are not usually of a good shape, their legs generally being too long. The breeders of the Nellores apparently aim at height rather than quality in the animals they rear. Occasionally a well formed compact animal of this breed is met with, but such animals are rare; those usually seen having flat sides, long legs, narrow chests, with badly formed hind-quarters drooping away at the tail.

245. Were more care exercised by the breeders of the Nellores, a very useful race of animals might be provided for the requirements of an improving agricultural practice. The Nellores are useful for draught, but they are slow. Owing to the weakness of their legs they are not so powerful for their size as some of the smaller races of cattle. The Nellore however is very docile, and can readily be trained for almost any kind of work. A good draught bullock of the breed, will weigh from 600 to 800 lb. Live

weight or about three times the weight of a draught bullock usually met with over Southern India.

246. Sometimes, a cow of the Nellore breed proves to be a good milker both as regards yield and quality of the milk, but usually the cows possess but low qualifications as dairy animals.

247. If the breeders would select the cows that possess good dairy qualifications, and put them to bulls whose mothers were also known to be good milkers, a milk-producing race could, in time, be established.

248. The influence of the Nellore breed has extended to the cattle of the districts around Nellore, and in many of the larger towns of Southern India the Nellores are extensively employed.

249. The cattle of the Mysore breed are not so tall as those of the breed just referred to. They are however of a much better shape than the Nellores, are more compact, wider at the chest, deeper in the girth, and much stronger in the hind-quarters.

250. Mysore cattle are usually very active, but are sometimes wild and difficult to manage. When once brought under control they are good workers and possess great endurance. In the length of their horns from 20 to 30 inches and in the form of their horns rising up and meeting near the points, the Mysore cattle can readily be distinguished from those of the Nellore race, the horns of which are always short and stumpy and seldom of a greater length than 9 inches. In colour Mysore cattle are usually a blackish grey. The Mysore cattle are employed chiefly for draught purposes; they are

much esteemed as coach cattle, on account of their activity and endurance. The cows are not valued for the dairy, as, they are usually so irritable and their yield of milk small. Good cows are however sometimes met with of this breed, and a race of dairy cattle might be established of this breed, as well as of the Nellore breed.

251. By crossing the two breeds together, a useful description of animal is obtained which possesses the tractability of the Nellore and the activity of the Mysore.

252. Other races with local reputations are met with in different parts of the Presidency, but they possess no marked peculiarities distinguishing them from the cattle met with generally over South India.

253. Nearly everywhere in South India the management of cattle is bad. Fodder crops are never reared for them; while the pasturage is in the hot season dry and scanty and in the cold season rank and coarse. Usually the food of the ryot's cattle consists of nothing more than a little dry straw, the refuse water in which rice has been boiled, and such scanty supplies of grass as can be collected on the half-burnt up plains to which the cattle are sent daily, sometimes to considerable distances, to pick up what they can find. No care is exercised in breeding; the bulls are not usually converted into bullocks until when about 5 or 6 years of age, and all bulls are indiscriminately used for breeding purposes. If the ryot could be induced to have all the young bulls unfitted for use in breeding castrated before 6 months old, much good would result,

as only the selected bulls could then be used for breeding.

251. There are few countries which possess such advantages as this for producing fodder. We have a wide choice of excellent fodder plants which are hardy and very productive. There is no difficulty in producing excellent green fodder at a cost of from 3 to 5 rupees a ton, a quantity sufficient for the requirements of an ordinary bullock from 3 to 4 months during the dry season. Such being the case, there is no justification at all, in most instances, of the ryot's conduct in allowing his cattle to sink so low in condition during the dry season.

255. Before selecting a bull for use in breeding, the breeder should settle in his own mind exactly to what purpose he intends to devote the animals he intends to breed. If he wants draught stock, then he must take care to select a bull with a good wide chest, well arched ribs, straight, well-formed back, strong hind-quarters, well proportioned legs set well apart, and standing on good feet. Width of chest is advisable, because thereby plenty of room is secured for the action of the lungs, and when the ribs are well arched space is afforded to the digestive organs; when the back is straight from the hump to the root of the tail, the hind-quarters are usually far more powerful, than when the animal droops behind from the hip to the tail as is so common. You will readily understand, that when the legs are too close together, or are too slight or too long, the weight of the body is not properly balanced or supported. In selecting a bull for breeding dairy

stock, width of chest is not considered so advantageous, it having been found that narrow-chested cows are frequently good milkers, and it has therefore been concluded that width of chest predisposes the animal to the production of flesh rather than to the production of milk. However a good width at the loins is desirable. By better feeding and by the selection of the males to be used for breeding, the ryot could at little expense effect much good in improving his cattle stock, so invaluable to him, as upon his cattle he depends entirely for the culture of his land, the conveyance of much of the produce he raises to market, and for the greater part of the manure he uses in his farming operations.

256. South India possesses several varieties of sheep. One of these varieties the characteristic points of which are black legs, black face, and white wool, is met with most abundantly in the Coimbatore District. These sheep are very small, and are not generally much appreciated as mutton-producers; while the yield of wool is not more than 1 lb. per head per annum. These sheep are usually kept by the ryot merely as manure-producers, being hurdled at night on land intended to be cropped.

257. Another variety of sheep called the Nellore breed is a long-legged animal, resembling a goat very much in general appearance. By the two skin tassels suspended from the neck, the sheep of this breed are readily distinguished. They are usually white and have a scanty covering of short wool, largely mixed with hair. The breed is hardy, but an unprofitable one in districts where the food

available will suffice for the Mysore, or any other breed of a superior character. The mutton of the Nellore sheep is very coarse and inferior.

258. In Mysore a useful breed of sheep is found. They are larger than the sheep of the Coimbatore breed and yield more wool, while they afford mutton of a superior quality. It is probable that the Mysore breed of the present day owes some of its qualities to the use of imported rams, which, at various times during the last fifty years, have been experimented with in that province.

259. Over South India generally a red colored goatlike sheep is common. This sheep produces no wool worth shearing. On the back and shoulders there is usually a tufty growth of wool and hair, but the remainder of the body is very scantily covered. These sheep are very hardy and manage to keep in fair condition on very inferior food, of which no inconsiderable proportion is furnished by brushwood and low-growing shrubs. When better fed and if killed before too old, these sheep yield moderately good mutton especially when in the case of males castration has been performed while the animal was young. Unfortunately, however, this operation is frequently so long delayed that the quality of the mutton is much injured.

260. The faults, already noticed in the ryot's management of his cattle, are as conspicuously shown in his management of his sheep stock. No care is exercised in breeding; the males and females being kept in one flock, young and old altogether. No crops are ever produced for the sheep. The food

they get is only such as they find growing on the poor pastures of the district, or on the banks of tanks, road sides, in the jungles, &c. By carefully selecting the rams and keeping them apart from the breeding ewes, excepting at the breeding season, much good could be done at a very moderate expense. Again, in many localities, sheep of the inferior varieties are kept, which might with great advantage be replaced by those of a better variety as, for instance, the Mysore, which yields good mutton and a fair amount of wool.

261. Much more might have been profitably stated *regarding our different varieties of farm stock, but* we cannot devote more time to the subject, and must pass on to consider briefly the means whereby the *animals obtain materials for their growth and support.*

262 Air, water, and food are essential to the preservation of life. The animal body may be compared to a furnace which must afford a given amount of heat and which therefore must regularly be supplied with fuel. Much of the food taken by animals is used up in the body in maintaining its heat. The portion of the food that fulfils this office is called respiratory or heat-producing, and it consists chiefly of the digestible cellulose, starch, and sugar. If more of this food is taken by the animal than suffices for maintaining the heat of its body the excess is stored in the form of fat.

263. Every part of the animal is constantly undergoing change; it is necessary therefore to supply in the food the material needed for forming the fluids of the body, the flesh, &c ; these, the

nitrogenous portion of the food supply; this consists of gluten, albumen, &c., constituents of all our fodders, grains and pulses, and in a larger degree of oil cake.

264. The *mineral matter* required for replacing the wastage thus going on constantly in the animal body, and for building up the frame of young animals, is obtained from the food which always contains some mineral matter, which the plant has obtained from the soil. When the soil is rich, the plants produced on it contain a sufficiency of bone material, but usually in this country cattle are grazed on plants produced on very inferior soil, and the consequence is that such animals do not obtain a sufficiency of bone material for the requirements of their bodies especially if growing, hence the small wretchedly formed animals so frequently seen.

265. But besides heat-producing food, and *flesh* and bone producing foods, animals need also fat-producing food, and the best way of supplying this is to give them oil cake, of which there are many varieties suitable for feeding cattle in this Presidency; the oil of the cake will in the body at once form fat.

266. You must remember that young growing animals need a sufficiency of food to supply the daily wastage in their bodies, as well as sufficient to supply the materials for building up the structure of their bodies.

267. In a well arranged diet, there should always be a proper proportion of heat-giving, fat-forming, *flesh-forming, and bone-producing constituents* in the food.

268. Plants and animals are composed of the same iemical elements. The plant collects the raw material, and prepares it for the use of the animal. The flesh of animals may be looked upon as the concentrated essence of plants.

269. It must be remembered always, that it is not the quantity of food eaten, but the proportion of that food which is assimilated in the body, upon which the health and growth of the animal depends.

270. In the ruminants, that is the ox, goat, and sheep, the food is chewed a second time. With these animals the food when in the mouth is torn or ground by the teeth and the action of the jaws, and is worked with the saliva into a pulp, during the process the starch of the food being through the agency of the saliva converted into sugar. The half *masticated food passes then into the first stomach,* from which after undergoing certain changes it enters the second stomach, where it is stored until again returned to the mouth to be re-chewed. After the food has undergone the second chewing, it passes direct into the third stomach, and from it into the fourth stomach where it finally undergoes exposure to the action of the gastric juice. From the fourth stomach the food enters the intestines, in which the useful portions are separated, and the useless matter rejected in the form of solid excrements. The portion of the food separated and absorbed while in the intestines, is finally mixed with the blood and is carried all over the body. The materials for making flesh, bones, milk, &c., are taken up from the blood.

271. The blood in circulating over the body passes through the lungs, and in doing so parts with its waste material it had collected in its circuit over the body. This waste material, in the act of breathing is expired into the air, and is replaced by fresh air breathed in at the time. This explains why the respired air, contains more carbonic acid than the air breathed in, the carbonic acid being the waste material removed from the blood. The blood which before passing through the lungs, is a dark color, becomes a bright red after undergoing the purifying process, when it again circulates over the body under the influence of the action of the heart.

Terms and Technicalities used in Scientific Agriculture.

A.

ABORTIVE.—Failing to reach a state of maturity or perfection.

ACCLIMATIZE.—To accustom a plant or animal to a climate not natural to it.

ACRE.—A quantity of land containing 4,840 square yards.

AGRICULTURE.—The art or science of cultivating the ground in view to the production of certain crops needed for the food, clothing, &c., of the human race; it includes also the rearing, feeding, and general management of farm stock.

ALBUMEN.—A nitrogenised compound of great value in the diet of man and of animals.

ALLUVIAL.—Matter brought together by water.

ALUMINA—Is the oxide of the metal aluminium; is the basis of clay.

AMELIORATE.—To improve.

AMMONIA—Is composed of three equivalents of nitrogen and one of hydrogen. Is of great value as a manure.

ANALYSIS.—The separation of a compound body into its constituent parts.

AQUATIC.—Pertaining to water or inhabiting water.

AQUEOUS.—Pertaining to, or formed under, water.

ARABLE.—Ploughed land.

ARGILLACEOUS.—Clayey.

ASSIMILATION.—The process by which bodies convert other bodies into their own nature and substance.

ATMOSPHERE.—The air around us.

B.

BEDDING.—Litter spread on the floor of cattle-sheds, &c.

BREED.—A race from the same parents or stock.

BROAD-CASTING.—Sowing seed or spreading manure by hand over the whole surface of the land.

Brushwood.—A thicket of small trees and shrubs; also branches of trees cut off.

Budding.—The act of inserting a bud of one tree within the bark of another for propagation.

Bullock.—An ox, or castrated bull.

C.

Calcareous.—Composed of lime chiefly.

Calcine.—To convert into a powder or friable state by the agency of heat.

Calcium.—The metallic basis of lime.

Capillary.—Hair-like. Applied to tubes less than $\frac{1}{20}$ of an inch in diameter, capable of attracting or maintaining any liquid above its natural height.

Carbon.—One of the elementary substances. Forms greater part of charcoal. Occurs largely in nature in animals and plants.

Carbonate.—Any compound of carbonic acid with a base as carbonate of lime.

Carbonic Acid—Is the gas given off from soda-water; is formed by the union of carbon with oxygen.

Cast-iron.—Iron which has been cast into moulds for various uses.

Castrated.—Gelded; emasculated; deprived of the power of propagating.

Catch-drain.—A drain for collecting surface water.

Caustic.—Burning.

Cellulose.—Woody-fibre.

Cereal.—A plant belonging to the cereal or grass order, for instance paddy, cholum, wheat, &c.

Chalk.—A soft kind of limestone.

Chlorine.— A greenish yellow gas contained in common salt.

Condition.—State in respect to quality.

Constituent.—That which constitutes or composes as an essential part.

Crop.—The corn or fruits of the earth collected; anything cut off or gathered.

CROSSING.—Producing young from different varieties of the species.

COULTER.—The knife-like part of the plough with a sharp edge that cuts the earth vertically.

CULTIVATOR.—One who tills or prepares lands for crops.

D.

DAIRY.—The place or room in which milk is kept and where it is converted into butter or cheese.

DECAYING.—Passing from a sound state to a worse condition.

DECOMPOSITION.—The separation of the constituents of a compound body.

DEGENERATE.—Fallen from a higher or better state.

DELTA.—The alluvial land formed at the mouth of a river.

DIGESTION.—Process of dissolving food in the stomach.

DISINTEGRATION.—The separation of the parts of a substance.

DORMANT.—Sleeping, at rest.

DRAUGHT.—The force required to move an implement, machine, &c.

DRESSING.—Manure, soil, &c., spread over land.

DRILLS.—Lines of plants in a field.

DROUGHT.—Dryness; absence of rain.

E.

EFFLORESCENCE.—Saline excrescences on the surface of land in the dry season.

EWE.— A female sheep.

EXCREMENTS.—That which is discharged from the animal body after digestion.

EXHAUSTING.—Impoverishing.

F.

FARM.—A tract of land cultivated by, usually, one tenant or owner.

FARM-MANURE.—Manure made on the farm consisting of animal excrement, litter, vegetable refuse, &c.

Farm-stock.—Cattle, sheep, and goats constitute the farm-stock of Madras.

Felspar.—A rock constituent composed of silica, alumina, with potash or soda, and a little lime, magnesia, and iron.

Fertile.—Productive.

Fertilizing.—Enriching.

Fibrine.—A nitrogenous organic compound.

Fibrous.—Consisting of fibres.

Field.—A piece of land enclosed for tillage or pasture.

Filter.—A strainer for removing suspended matter from liquids.

Fodder.—Green or dry stems, and blades of plants, used for the food of stock.

Forage.—Food of sorts used by stock, such as corn, hay, fodder, &c.

Forest.—A large tract of land covered with trees.

Formation.—A single mass of one kind of rock.

Friable.—Easily crumbled.

Frost.—Frozen dew.

Fuel.—Combustible matter.

Furrow.—A trench in the soil made by a plough.

G.

Gastric Juice.—A fluid produced in the stomach by which the food is dissolved.

Generation.—The act of begetting; a single succession in natural descent, or the children of the same parents.

Germinate.—To sprout; to vegetate; to begin; to grow.

Gluten.—A tough elastic substance of a greyish color found in wheat and other grains.

Gneiss.—A rock formed of quartz, felspar, and mica mixed up together.

Grafting.—Inserting a shoot, or cutting, into another tree of the same species.

Grain.—A single seed of those kinds used as the food of man or animal.

Granite.—A rock composed of quartz, felspar, and mica, each in separate grains.

Granular.—Consisting of grains.
Gravel.—Water-worn rock fragments, from the size of a pea to that of a hen's egg.
Gravitation.—The tendency of all matter in the universe toward all other matter.
Grazing.—Pasture.
Gum.—Mucilage of vegetables.
Gypsum.—Sulphate of lime.

H.

Hedge.—A line of thorn bushes or other shrubs forming a fence.
Heifer.—A young cow before she produces a calf.
Herbivorous.—Herb-eaters.
Holding.—A farm.
Humus.—The black powder formed when a piece of wood is partially decayed.
Husbandman.—One who cultivates a farm.
Hybrid.—The offspring of two nearly allied species whether animal or vegetable.
Hydrogen.—One of the elementary gases. With oxygen it forms water.

I.

Infusoria.—Minute animal organizations.
Implement.—Tools or instruments of labor.
Irrigation.—The operation of causing water to flow over land for nourishing plants.

L.

Larva.—An insect in its grub, caterpillar, or maggot state.
Laterite.—A peculiar clayey deposit of a reddish brown color. Is composed chiefly of clay and iron.
Layer.—A stratum; a bed.
Leguminous.—Pod-bearing plants are leguminous.

Lime.—A chemical combination of calcium with oxygen; occurs in nature as carbonate of lime.

Liquid-excrement.—Urine of stock.

Litter.—Bedding placed under stock in sheds.

Live-weight.—The weight of an animal when alive.

Loam.—A soil that contains a fair admixture of clay, sand, and vegetable matter.

M.

Magnesia.—An earth having for its base the metallic substance magnesium.

Manure.—Anything which acts directly or indirectly in fertilizing land.

Marl.—Any soft admixture of clay and lime is termed a marl.

Masticate.—To chew; to grind in the mouth.

Mature.—Brought to perfection.

Mica.—Is a constituent of granite. Has a lustre; divides into thin flakes.

Mineral.—Inorganic substance not formed by vital forces.

Molecule.—The smallest visible particles of a body.

Mould-board.—The part of the plough which receives the soil from the share and raises, turns, and moulds it.

Mud.—Wet slimy earthy matter.

N.

Nitric Acid.—A strong acid formed of nitrogen and oxygen.

Nitrogen.—One of the gases of the atmosphere, of the volume of which it constitutes 79 per cent.

Nutriment.—Food.

O.

Offal.—The part of an animal unfit for use.

[illegible]—A shoot or sprout from the root of a plant.

Organic-matter.—Vegetable substance.

Ox.—A bullock. A castrated bull.

Oxide.—A compound of oxygen and a base.

Oxygen.—The vital part of the air of which it forms 21 per cent.

P.

Passive.—Inert.

Pasturage.—Grass land.

Peat—Is formed by the partial decay of marsh plants in cold countries.

Phosphoric Acid.—An acid formed of oxygen and phosphorus.

Physical.—Perceptible to the senses.

Ploughshare.—The part of the plough which cuts the earth at the bottom of the furrow.

Porosity.—Having pores or openings.

Potash.—A mineral that enters largely into the composition of most agricultural plants.

Poudrette.—The solid excreta of man dried and deodorized by means of charcoal, ashes, &c.

Propagated.—Multiplied.

Property.—Attribute.

Pulse.—The seed of a leguminous plant.

Q.

Quartz.—Silica.

R.

Race.—A generation. The continued series of descendants from a parent.

Ram.—A male sheep.

Respire.—To breathe. To inhale air into the lungs and exhale it.

Ridges.—A strip of land raised up by a plough.

S.

Saline.—Containing or impregnated with salt.

Saliva.—The fluid secreted in the mouth.

SALT.—Common name for chloride of sodium.

SALTPETRE.—Common name for nitrate of potash.

SANDSTONE.—Consolidated sand formed under pressure, or held together by a cementing matter.

SCRUB JUNGLE.—A thicket of small shrubs.

SECTION.—A division.

SEDIMENT.—Matter settled from water.

SHEARING.—Clipping.

SHRUB.—A dwarf tree.

SILICEOUS.—Composed chiefly of sand.

SILT.—Fine impalpable mud, which sometimes collects on water settling.

SLACKED.—Deprived of cohesion.

SODA.—A white powder found in common salt.

SOIL.—The loose earth which is moved in tillage.

SOLID EXCREMENTS.—Dung.

SPECIES.—A group of individuals resembling each other, capable of exact reproduction by natural propagation.

STAGNANT.—Motionless; not flowing.

STARCH.—A white substance found in many grains.

STERILE.—Not fertile; not capable of reproducing.

STEMS.—The main stalk of a plant.

SUBMERGED.—Under water.

SUBSOIL.—The layer of soil resting beneath the layer stirred by the tillage implements.

SUBTERRANEOUS.—Lying under the surface of the earth.

SUCKER.—The shoot of a plant from the lower part of the stem.

SUGAR.—A sweet substance of vegetable origin.

SULPHURIC ACID.—An acid formed of sulphur and oxygen.

SWAMP.—Low lying land saturated with water.

SWING-PLOUGH.—A plough without a wheel.

T.

TABLELAND.—Elevated flat land.

TENACEOUS.—Sticky; tough; adhesive.

TERRACE.—A shelf of land with a uniform level surface.

TOP-DRESSING.—A dressing of manure laid on the surface of land.

TURN-WREST PLOUGH.—A plough, the mould-board of which can be used on either side of the beam.

U.

UNDER-DRAINAGE.—The removal of water from beneath the surface of the land.
UPLAND.—High land.
URINE.—The liquid excrement of stock.

V.

VALLEY.—Low lying land in a hollow.
VITALITY.—Life , animation.

W.

WOODY-FIBRE.—Cellulose
WOOL.—Soft hair produced on the back of sheep.
WORKED.—Tilled.

INDEX.

Para.

AGRICULTURE, definition of the term and objects of 1
  Rude systems of, suffice when only good land tilled and population scant 7
AIR, composition of .. 72
ASHES, wood .. 107, 196
B[illegible]ES, manural uses of .. 184
BREEDING, selection of cows 247
  Selection of bulls .. 255
CARBONIC ACID 73
CATTLE, Nellore .. 244
  Mysore 249
CLAY 49
  soils of 86
  not suited for irrigation 89
CROPS 212
  propagation of .. 214
  rotation of 227
  restorative 232
  exhaustive 233
  fodder 254
DRAINAGE, under .. 118
  prevent saline efflorescence 120
  aeration of soil by .. 121
  reduces expenses of tillage 122
DUNG OF CATTLE .. 179

Para.

DUNG OF CATTLE
  destruction of as fuel .. 183
EXCRETA OF MAN 104,105
HARROW 156
IMPLEMENTS, draught of 56
  few kinds in use .. 130
  those suited for small farms .. 133
  cost of work done by 1[illegible]
IRRIGATION WATER
  should pass through the soil .. 123
  action of .. 203
  great waste of .. 208
LAND
  virgin land getting scarce 4
  inferior needs to be well farmed .. 7
  in low situation, enriched by silt, washed off higher land .. 82
  preparation of for culture 101
  clearing forest .. 103
LIME, action of .. 20,180
MADRAS
  agricultural population of 2
  cropping of 220
  live stock of .. 240
MANURE
  farm 29,176

Para.

MANURE
green .. 30,202
action of 173
OXIDE OF IRON .. 63
PLANTS
ash of 167
food of .. 160,172,224
composition of .. 216
PLOUGH
Native 143
working parts of .. 149
native, only stirs, does not turn soil .. 152
cost of work done by great 153
PLOUGHING
when deep advisable .. 21
sub-soil 25
cost of, by improved plough 139
POPULATION
agricultural 2
great increase of, in recent years .. 3
food for, great increase of, supplied by increasing the area of the tilled land .. 3
should supply food for, by higher tillage .. 5
ROCK, decomposition of .. 60
ROLLER 158
SALT 201
SALTPETRE 200
SEED
vitality of 212
sowing of 213

Para.

SEED
germination of .. 222
SHEEP
Nellore 257
Coimbatore 256
Mysore 258
SILT, carried by water 31,210
SOIL
great variety of .. 8
advantage of pulverizing 22
alluvial 33
peaty 37
loamy 40
sub-soil 44
constituents of .. 51
free 56
heavy 57
formation of 70
classification of .. 99
mixing of 113
exhaustion of .. 171,186
black, character of .. 11
management of .. 22
red 50
sandy 91
many grades of, fertility of 93
suited for irrigation .. 94
Calcareous 97
peaty 125
STOCK
live 237
diet of .. 203,207
SUB-SOIL
porous 52
retentive 53

Para.

TILLAGE LAND
  great increase of, in recent years .. 3
  cheap by improved plough 141
  effects of .. 161,166
TREES
  influence of, on climate 104

Para.

TREES
  fruit or fuel 108
  as soil improvers .. 126
URINE OF CATTLE .. 178
VEGETABLE MATTER, uses of, in a soil .. 16,47
WARPING 128
WATER, stagnant .. 114